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CONTENTS.

	PAGE.
Nutrition and Health	29
A Brief Study of the Yield Factors Involved in a Manurial Trial	31
Notes on the Physiology and Biochemistry of Tropical Fruits—I. Avocados	34
The Banana Leaf Speckle in Surinam caused by *Chloridium Musae* Nov. Spec. and another related Banana Disease	42
Reviews	45
The Late Dr. Briton-Jones	46
The Cacao Industry of Trinidad	47
Method of killing Standing Trees	50
Humus	52
Sugar Notes	53
Miscellaneous Notes	54
Chemical Notes	55
Trend of the Markets	56

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NUTRITION AND HEALTH.

GOVERNMENTS have for many years provided all kinds of public services but it is only recently that they have been called upon to devise means for securing the community from hunger and from ill health associated with inadequate dietary. It is strange that so little attention has officially been paid to this problem in the past but it must be remembered that the scientific study of nutrition only began in earnest during the last century. Thirty years ago it was still generally believed that the dietetic requirements of human beings were satisfied as long as they had enough to eat, although by that time Lavoisier's classical experiments on the functions of food in the human body made at the end of the eighteenth century, and Liebig's nutritional studies begun in 1840 were already known. Liebig's views, however, greatly differed from our own and between his days and the close of the nineteenth century much good work was done on nutritional problems, at first in Germany and later in the United States. Within the present century considerably more progress was made in the field of nutritional science, especially during the War when Governments had not only to feed large armies whose physique and morale had to be maintained but also had to ensure an adequate food supply for the civilian population. Still more recently the world economic crisis and unemployment have imposed further responsibilities on Governments in the sphere of public assistance of which the most urgent has been the combating of malnutrition. In this connection the Health Organisation of the League of Nations has for some years now been engaged on the study of nutrition in relation to public health and as a result of its investigations the problem has attracted considerable public attention. Sir John Orr, for instance, in a remarkable address to the British Association stated that in 1935 there were some twenty million people, who, largely owing to poverty did not enjoy a diet which according to the modern science of nutrition was completely adequate for health. In view of the glut of all kinds of foods in the world such a statement is rather disturbing and it is not surprising to find that a little later that year Mr. Bruce, during a debate which took place at the Assembly of the League of Nations spoke of the benefits which would come of "a marriage of health and agriculture" in the belief that a practical treatment of one question might help to solve the other. At the conclusion

of this debate the Assembly adopted a resolution urging all Governments to examine the practical means of securing better nutrition. Following upon this, a circular despatch from the Secretary of State was sent out early last year to every British dependency on the subject of nutrition, and it has been left to committees appointed locally to consider this problem in relation to public health and especially its bearing upon agricultural, veterinary, educational and general policy in the Colonial Empire.

According to our existing knowledge of nutrition the adequacy of a dietary depends on the presence of a number of factors one of the most important of which is the provision of ample protective foods, especially dairy produce, fresh vegetables and fruit. The absence of such foods from a man's dietary may render him an easy prey to infectious diseases or impair all his capacities and his efficiency for any form of activity: their absence, furthermore, has especially deleterious effects upon children and upon nursing and expectant mothers. In the more advanced tropical countries much important work on nutritional problems has been, and is being carried out. Measures for the control of beri-beri in Malaya were an early example in the dietetic field of the application of scientific knowledge to public health questions on a large scale. In Trinidad, Seagar's* investigations at the College in 1930 on labour efficiency threw some light on the subject of the dietary of Trinidad labourers. In brief, he noted a low calorific value, an excess of carbohydrates and a deficiency of fats, proteins and vitamins and established that faulty diet was one of the important factors influencing the degree of labour efficiency. He also stressed the need for educative measures to persuade workers that a diet which appeared to satisfy them might yet be unbalanced and was consequently inadequate for the preservation of health. In 1935 a Committee was appointed to make a survey of the general dietary and constitutional conditions of East Indian labourers in the various centres of the Colony. This Committee found that the diet of the East Indian labourer was ill balanced, consisting as it did almost exclusively of carbohydrates while food of animal origin was almost entirely absent. The diet was reported to be grossly deficient in the superior proteins and animal fats and in all the vitamins while the quantity of milk supplied to infants and young children was stated to be wholly inadequate. The causes of the deficient diet were declared to be a preference for carbohydrates and the neglect of other available foodstuffs necessary for proper nutrition due to custom and thrift. It was also found that the dietary led to certain recognised specific signs of deficiency diseases and the prevalence of a peculiar chest condition. It was suggested that the first step towards reform must be education since without such preparation remedial measures would prove neither beneficial nor economical. It will be evident from these investigations that there is considerable room for improvement in the dietary of labourers in this and most likely other parts of the West Indies.

The question arises as to how this improvement is to be brought about. Educative measures have already been stressed and in all probability nutrition campaigns will be organised where the help of public health and agricultural officials, practitioners of medicine, health nurses, school teachers and social workers will be enlisted. Other most pressing problems will include the determination and recognition of nutritional needs, the assessment of, and the best methods of utilising, the resources available to meet such needs and the provision, where necessary, of additional resources to meet new food requirements. All these problems are already being studied by the Trinidad Nutrition Committee which has been requested, as many other committees appointed throughout the Colonial Empire to furnish the Secretary of State with a comprehensive review of the problem of nutrition in the Colony. The reports submitted by the various Colonies will eventually be considered by a Committee of the Economic Advisory Council, recently appointed by the Prime Minister with the object of surveying the present state of knowledge in regard to nutrition in the Colonial Empire, and of advising from time to time on the means calculated to promote the discovery and application of knowledge in this field.

From the agricultural point of view, apart from putting practical measures into effect such as the provision of an adequate supply of fresh milk which is generally a crying need in the tropics, and encouraging the production of local foodstuffs there should be plenty of scope for suggesting lines of research on certain problems on which as yet little is known. There is, for instance, still a great deal to be learnt on the dietetic values of tropical foodstuffs especially in relation to the possible effects on the composition of such foods which have been grown with different kinds of fertilisers. Some useful information might also be collected on the effect of storage on the dietetic values of foods and on whether toxic effects, if any, are produced as a result of the use of poisonous sprays.

Among backward peoples such as inhabit many parts of the African continent Sir John Orr states that " there is a world of nutrition work waiting to be done. Disease is as prevalent among tribal races as among civilized people, and there is clear evidence that not only would much ill health disappear, but better physique would result if the native food were adequate in quantity and quality. An improved supply of native foodstuffs depends upon an improved native agriculture designed to increase the supply of animal and vegetable foodstuffs rich in good proteins, vitamins and mineral matter. To direct African agricultural policy along the lines of increased production

* *Tropical Agriculture*, Vol. VII, No. 2, pp. 40-45.

and consumption of animal products would undoubtedly have far-reaching effects on the health of the native, which might not inconceivably influence the whole future development of the continent."

Whatever is done in regard to the improvement of nutrition in the Colonial Empire important changes in economic and agricultural policies are bound to take place. In particular, schemes will need to be devised for making supplies of protective foods available at prices within the reach of all classes without prejudicing the interests of producers. If necessary, also, the question of the re-orientation of agricultural production, with the view of satisfying the requirements of sound nutrition, will have seriously to be considered.

A BRIEF STUDY OF THE YIELD FACTORS INVOLVED IN A MANURIAL TRIAL.

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A special experiment was recently conducted by the writer at the Central Experiment Station, Réduit, with the object of investigating border effect in manurial trials. In this experiment there were two series of plots, four of series "A" and five of "B," the kinds of fertilisers applied being the same for both, but the "B" series received exactly four times the quantity applied to the "A", *i.e.* 850 kilogrammes per arpent against 212.5 kilogrammes per arpent. Even before the trial was reaped, it was obvious that the "B" plots would outyield the "A" plots by a large margin, so that it was considered that some other points might well be investigated. Actually at harvest, the average yield of all the "A" plots was 23.45 tons of cane per arpent, whilst that of the "B" plots was 40.2 tons, *i.e.* an increase of 16.75 tons. In this connection it is necessary to note that the field in question was one of reputed low fertility, so that it is very unlikely that such an increase would be obtained from a soil in a normal state of fertility.

Every plot in this experiment consisted of six rows, each containing 30 stools of sugar-cane (variety M. 27/16). For the purpose of considering the points discussed below, only the centre four rows were considered, and three stools were eliminated from the ends of the row on the windward side, and two stools from the other ends so that the plots consisted of 100 stools. By this means it was hoped to eliminate all border effects. The points to be discussed later may be grouped under two headings (*a*) the effect which the different applications have had upon the quality of the cane, and (*b*) how the growth of the stool as a whole has been affected.

(A) *Quality of the Cane.*—Cane samples were taken from all nine plots, each sample consisting of twelve canes from 100 stools. These samples were crushed in an experimental cane mill, and the juice analysed by the usual methods for sucrose, glucose and purity. Other determinations made were (*a*) P_2O_5 in the juice by the colorimetric method of Deniges and (*b*) K_2O in the juice by the cobaltinitrite method (1). The results obtained are given in Table I.

Table I.

	Sucrose % Cane.	Purity	Glucose Ratio.	Grs. P_2O_5 % mls. juice.	Grs. K_2O % mls. juice.
"A" plots ..	12.80	89	3.93	0.0041	0.025
"B" plots ..	12.61	91	4.44	0.0033	0.039

From the figures given in this table, it will be seen that there is a slight drop in the sucrose % cane in the "B" plots as compared with the the "A" plots, but this difference is quite insignificant, so that there is no evidence that the large amount of fertilisers applied to the "B" plots has had any ill effect upon the richness of the cane. The same may be stated with respect to both the purity and glucose ratio, so that from the manufacturing point of view, there is practically no difference in the juice from the differently treated plots.

It is, however, rather peculiar to find that the juice of the heavily fertilised plots is less rich in phosphoric oxide than that from the plots receiving the small applications of fertilisers, and judging from the results of a statistical analysis, this difference is significant. Somewhat similar results have been reported by Saint (2) in Barbados with the important difference that sugar-cane does not usually show any response to phosphatic fertilisers in that country. The experiment under discussion does not afford any evidence that lack of phosphate is definitely acting as a limiting factor, but the probability is that such is the case as young virgin canes growing in a small manurial trial adjacent to the one under discussion are showing definite response to phosphate fertilisers, and in general it is known that the soils of Réduit are deficient in available phosphate. This lower P_2O_5 content in the juice from the canes grown in the "B" plots is possibly capable of explanation on the grounds of interaction of other growth factors. It will easily be recognised that although the percentage of P_2O_5 is less, the total amount

of phosphoric acid taken up by the canes per acre in the "B" plots is greater than that absorbed by the canes in the "A" plots, so that if the other growth factors such as the nitrogen and potash status of the soil had remained constant, then a much smaller increase in yield would have been obtained, but the juice may have had an increased percentage content. The simultaneous application of extra nitrogenous and potash fertilisers may, however, have created a much better balance between the various available plant foods in the soil, with the result that any individual plant food may be used with the maximum efficiency. Should such prove to be the case, it would provide further evidence that the analyses of cane juice is not likely to be a reliable method for determining possible soil deficiencies.

In so far as potash is concerned the heavily fertilised plots contain appreciably more potash than do the highly fertilised ones, although the difference is not quite significant. According to Saint (2) in Barbados, the application of phosphatic fertilisers resulted in an increase of K_2O in the juice. The increased content of this element in the juice of the canes from the heavily fertilised plots may therefore be due to two causes: (*a*) the increased amount of potash in the fertilisers, and (*b*) the increased quantity of phosphoric oxide in the fertilisers.

If the figures given by Saint for the distribution of potash and phosphoric acid in the cane are applicable under Mauritius conditions, then the recovery of the extra potash and phosphoric acid applied to the "B" plots may be calculated, and it will be found that about 33% of the potash and between 1% and 2% of the phosphoric acid has been recovered in the cane. The remainder of the potash may possibly remain in the soil in the exchangeable form, or part may have been lost in drainage water. It is certain that the residue of phosphoric acid has been fixed in the soil in a form which is only available with difficulty, but the level of fertility with respect to phosphate will have been raised, so that in course of time the coefficient of utilisation of added phosphate may be improved.

(*B*) *Effect of the Different Applications on the Yield.*—It has already been stated that the heavily fertilised plots "B" outyielded the lightly fertilised ones "A" by nearly 17 tons per arpent, so that the trial should show some well defined indications as to the manner in which the individual stools have reacted to the various applications. Evans (3) has already shown that the coefficient of variability in sugar-cane amounts to nearly 50%, and even when the positional variation was eliminated by dividing the whole block into plots each containing 50 stools, it still amounted to 48.5%. In the trial under consideration, four plots, consisting of two "A" and two "B", were chosen for further investigation, and twenty five stools from each of the middle four rows were reaped and weighed individually. These data from 100 stools per plot were used for calculating the coefficients of variability given below:—

Plot No.			*Coefficient of Variability*
B. 3	....	....	38.7 %
A. 4	....	....	46.9 %
A. 6	....	....	60.0 %
B. 7	....	....	41.2 %

It will be seen from these figures that in each pair of adjacent plots, the variability is much less on the "B" plot than the corresponding "A," so that it would appear that a more uniform crop is produced when the canes are liberally fertilised than when small applications of fertilisers are made. It seems probable that this greater uniformity in the mature crop is due principally to the elimination of minor differences in soil fertility from spot to spot, especially with respect to plant food elements. There is no doubt that other aspects of soil fertillity, such as the supply of moisture, are also causes for increasing the inherent variability of sugar-cane stools and that if they could be eliminated, by means of very regular irrigation for instance, the coefficient of variability would be still lower. It might be remarked that germination in the trial was very regular, and that any recruits which were needed were supplied at a very early date.

In these same stools which had been weighed separately counts were also made of the total number of millable canes per stool, and also of the number of canes that had arrowed. Arrowing may have a certain depressing effect on the yield in that once a cane has started to arrow all normal vegetative growth and cane production ceases. Notes made whilst the crop was still growing indicate that the canes in the differently treated plots showed the first signs of arrowing at the same time, so that the different treatments had no marked effect upon the time of arrowing. When the canes were reaped it was found that 19% of the canes in the lightly fertilized "A" plots and 23% in the heavily fertilised "B" plots had arrowed. Although the standard deviations have not been calculated, it does not seem that the difference between the two series of plots is significant, as the variation between individual stools of one treatment ranges from 0% to 100% arrows.

The other factors which may be considered in connection with the yield are the number of canes per stool and the weight of the individual cane, the two together determining the actual weight of the stool, and therefore the yield per arpent. The average number of canes per stool in the "A" plots examined was 3.91, the standard

deviation of the mean being 0.13, whilst in the "B" plots the figures are 5.35 canes per stool, with a standard deviation of the mean equal to 0.18. The difference between these two sets of figures is highly significant, and it can therefore be confidently stated that one effect of the heavier application of the fertilisers has been to increase the number of canes per stool.

The individual canes were not weighed, but the average cane weight per stool may be calculated from the individual weight of each stool and the number of canes in it. The figures thus obtained were used for calculating the average weight of each cane and the standard deviations of the different means. In the "A" plots, the average weight per cane is 1.87 kilos, the standard deviation of the mean being 0.036, whilst in the "B" plots the corresponding figures are 2.57 kilos per cane, with a standard deviation of the mean equal to 0.046. The difference between the two means is certainly significant, and therefore it must be considered that the heavier application of fertilisers has resulted in bigger canes. Although there are no experimental data dealing with the dimensions of the canes in the differently treated series of plots, it may be stated as a result of personal observation that those of the "B" plots were not only taller but also thicker than those of the "A" plots.

It would thus appear that the increased yield in the the "B" plots is due to improvement in two directions, first the number of canes per stool has been significantly increased and secondly the individual cane is larger, being both longer and thicker. Incidentally, this trial is being continued in first ratoons, and it would appear from a visual examination that these results will be confirmed in the crop to be cut in the coming harvesting season. In some previous work, on the estimation of cane yields by means of cane counts and measurements, which has not been published a similar state of affairs was noticed. Thus an increased yield in this manurial trial with R.P.6 canes was attended by an increased number of canes per stool, and an increase in both length and diameter of the canes.

The actual increase in weight in the present trial may be analysed as in the following table.

Table II.

	Yield.	No. of canes per stool.	Weight per cane.
"A" plots	22.8	3.91	1.87
"B" plots	41.5	5.36	2.57
Increase of "B" over "A"	18.7	1.45	0.70
% Increase of "B" over "A" ..	82%	37%	37%

It will be seen that the increase due to each of these two factors is about the same, the two together accounting for 74 per cent. out of the total 82 per cent. increase, and it may be considered that the remaining eight per cent. is accounted for by the interaction of these two factors. In this trial, the heavier application has had no significant effect upon the amount of arrowing.

These results are somewhat different from those published by Evans in the Sixth Annual Report of the Sugar-cane Research Station, Mauritius, but in this case, the effect of a late large application of sulphate of ammonia was investigated, whereas in the experiment described in this paper different quantities of a balanced mixed fertiliser were used, and the final application was made in the December prior to harvesting. The reason for the different results obtained may therefore be due to these causes.

Summary.

A manurial trial conducted at the Central Experiment Station, Réduit, contained two series of plots, both of which received the same kind of fertilisers, but at different rates. The "A" plots which received 212.5 kilos of mixed fertilisers yielded 23.45 tons of cane per arpent, whilst the "B" plots, with 850 kilos of mixed fertilisers gave 40.2 tons of cane.

The sucrose per cent. cane, purity and glucose ratio were not significantly different for the two series of plots, but considerable differences with respect to the phosphoric oxide and potash content of the juices were noted. As was expected, the potash content of the juice from the "B" plots was almost significantly higher than that from the "A" series. Contrary to expectation, however, the phosphoric oxide was significantly lower in the juice of the "B" plots.

With respect to the effect of the heavier applications on the amount of arrowing of sugar-cane, it was found that there was no significant difference between the two series of plots, but there were more canes per stool, and the individual canes were heavier in the "B" plots. From the present appearance of the first ratoon crop, it would seem that these results will be confirmed during the coming crop season.

It was also found that a more uniform crop was produced in the "B" plots than in the "A" plots.

References.

(1) V. Olivier.—"Dosage de la potasse dans les jus et melasse des cannes." *La Revue Agricole de l'ile Maurice*, Juil-Aout 1934, p. 122.

(2) S. J. Saint.—"Juice Analysis in Relation to the Fertiliser Requirements of Barbados Soils." *Proc. 5th Cong. Int. Sug. Cane Tech.* Brisbane, 1935.

(3) H. Evans.—"Some Preliminary Data concerning the best Shape and Size of Plot for Field Experiments with Sugar-cane." *Bull. No. 3, Sug. Res. Station, Dept. of Agriculture*, Mauritius 1934.

NOTES ON THE PHYSIOLOGY AND BIOCHEMISTRY OF TROPICAL FRUITS.—I. AVOCADOS.*

By C. W. Wardlaw.
(*Low Temperature Research Station.*)

I. Composition and Dietetic Value.

Of all edible fruits, says Kellogg (19), the avocado stands pre-eminent as a source of concentrated nutriment adapted to human use, while Barrett (1) holds the view that in time the avocado will become one of the five great food fruits of the Tropics. The principal use of the avocado is as a salad fruit, being prized for its rich nutty flavour and smooth buttery consistency. In the countries to which it is indigenous it constitutes an important item in the native dietary.

The dietetic properties of avocados are peculiar, the high oil content, which may vary from two to 30 per cent. of the fresh weight (41) being equalled only by that of the olive, with which comparisons are frequently made. According to Mattill (22) the oil, though quite distinct from butter in composition, is equally digestible, while Kellogg (19) adds that it is quite free from the unpleasant butyric acid with which many fats are contaminated. The expressed oil of the avocado is similar in its chemical constitution to olive oil and may be adapted to similar uses, but the cost of extraction still prohibits its commercial utilisation in the manufacture of soaps and cosmetics (41).

Compared with such dessert fruits as black-berries, apples, bananas and grapes, the avocado shows important differences in respect of dry weight, ash, protein, oil and sugar content (17, 41).

Table I.

Percentage (Fresh-Weight) Composition of mature Avocados and other Fruits. (After Jaffa and Goss; and Wolfe, Toy and Stahl.)

Dry Weight.	
Avocado (California)	29.44 (17.69-41.29).
Avocado (Florida)	15-28
Banana	25.00
Black-berries	15.00
Protein (of fresh pulp).	
Avocado (California)	2.10 (1.14- 3.70).
Avocado (Bartley and Lyon varieties, California)	4.39
Avocado (Florida)	0.85-1.70
Grapes	1.40
Apple	0.30
Ash.	
Avocados (California)	1.32 (0.54- 1.94).
Avocados (Florida)	0.65-1.25
Bananas	0.84
Apples	0.30

Table I.—*Contd.*

Sugar Content.	
Avocado (California)	5.95 (2.59-10.00).†
Avocado (Florida)	1.52-2.0
Black-berries	6.00
Bananas	20.00
Fat Content.	
Avocado (California)	20.06 (9.78-31.60).
Avocado (Florida)	4.77-18.77
Avocado (West Indies)	7.60 (maximum) ‡
Sweet fruits	0.20-1.40

From these data it will be noted that the avocado leads, not only in respect of protein, of which three different types have been isolated by Jones and Gersdorff (18), and ash content, but also, since the energy value of fats is more than twice that of carbohydrates, that it stands high among energy-producing foods. Among the better Californian varieties, the fat content exceeds that of good varieties of olive (17).

The calorific value of the avocado, estimated at 73 calories per oz., is nearly three times that of the banana, one and a half times that of beef-steak and other meats, and three times that of several kinds of fish. Because of this high calorific value and its low carbohydrate content, the avocado is regarded as an admirable food for diabetic cases (41).

The high iron content, 0.0015 per cent. of the edible portion, is physiologically in a highly available condition and represents about three times that found in other common fruits. According to Weatherby (38), this should make the avocado valuable in the prevention or treatment of anaemia. The presence of vitamins A (abundant), B (abundant), C (traces), D (fair) and E (good) in the Fuerte, the standard variety in California, also adds to the usefulness of the avocado as a food (35, 36, 39). The vitamin A content is said to be sufficiently high to provide resistance against bacterial infection, a quality possessed by few vegetable fats and one in which olive oil is said to be lacking (19).

The percentage of mineral matter in the avocado is much higher than that recorded for any other fresh fruit, the proportion of useful, base-forming elements being high, nearly one half of the ash content consisting of soda (18.55 per cent.) and potash (26.23 per cent.). Phosphoric acid averages 17.5 per cent. and iron 1.5 per cent. (17).

† Described as carbohydrates but also including crude fibre, about 1.5 per cent. (Jaffa and Goss).

‡ *See* Freeman (9).

* These notes are essentially a review of the more important literature.

Sugars.—The percentage of total sugars, which is generally a small amount, from less than one to three per cent., decreases slightly during development and maturation. Nearly all of the sugars found is in the form of free reducing sugars (30), only a small amount of hydrolysable sugar being present, and that chiefly in mature, stored fruits which have become soft.

II. Fat Content, Race and Environment.

A large number of analyses of avocados have now been made in Florida and California. Stahl's (29, 30) determinations of the range in weight, moisture, fat, ash content, &c., for the more important Florida varieties is indicated in Table 2.

Table 2.

Analyses of Florida Avocados (based on fresh weights). (After Stahl.)

Weight (pounds)	0.67- 1.71
% Seed	8.56-24.36
% Skin	9.42-15.44
% Edible Pulp	63.32-77.72
% Ash	0.64- 1.23
% Moisture	72.47-85.05
% Fat and Oil (ether extract) green basis	4.77-18.77
Do. dry basis....	31.39-67.46
% Total Sugar	1.52- 1.92
% Protein	0.86- 1.71

Stahl comments that, under Florida conditions, there is no absolute correlation between fat content and race*. In general, West Indian varieties, native to moist tropical lowlands, possess the lowest fat contents, four to seven per cent.; Guatemalan varieties, indigenous to tropical highlands, have from 10 to 13 per cent.; and Mexican varieties, indigenous to highlands and possessing a higher degree of cold resistance, have from 12 to 15 per cent. Exceptions, however, occur in all three races. Further, the same varieties grown in California, Florida and the West Indies have quite different fat contents, the Californian-grown fruit showing the highest values, and that grown under West Indian conditions the lowest. Of Trinidad fruits (9) which have been analysed, the richest contained only 7.6 per cent. of fat, a figure which lies below the minimum for Californian varieties. Introduced as well as local varieties in Trinidad are characterised by a low fat content. It may be concluded that the variation encountered in this important characteristic is partly a matter of genetic constitution and partly a response to climatic conditions.

It has been observed that Florida varieties develop and mature in a shorter time than the Californian varieties (41). Studies of developing fruits show that there is a steady increase in fat content while the fruit enlarges on the tree, even when it is allowed to remain until well past the normal harvesting time for the variety (41). The fat content in any particular variety may show marked variations from year to year, as much as two per cent. for varieties with comparatively high fat content, and about one per cent. for those with low fat content. Wolfe, Toy and Stahl (41) consider that such differences are related to the difference in date of setting seed and hence to the length of development during two seasons. "The variation shown in fat content of fruit grown in different localities is much less for any given date than the variation on this date from one year to another, but is less than ten per cent. of the total fat content of the fruit in either case."

High fat content is not necessarily an indication of good quality, some of the most prized varieties being poor in this respect. So far the evidence affords no indication of a direct correlation between fat content and palatability. Stahl's (29, 30) analyses show that fruits with high fat content usually possess also a high ash content. On the other hand no relation could be established between fat content and sugar or protein values.

III.—Changes during Development.

The most outstanding feature of the development of the avocado fruit is the increase in the fat content. While the fruit is immature this takes place rapidly but with greater maturity the rate of accumulation decreases. Fat accumulation is accompanied by a decrease in sugar content (2, 3, 4).

Working with Florida avocados, Stahl (30) found that the ether-soluble fat content, calculated on a wet basis (*i.e.*, as percentage fresh weight), which increases considerably during development, is accompanied by a corresponding decrease in the moisture content. If, however, the fat values are expressed on the dry (*i.e.*, water-free) basis, the increase during development is less pronounced, indicating that the moisture content of the fruit must also be taken into account where fat content is being used as a measure of maturity.

Again, when the same variety of avocado is grown under dry and moist conditions in Florida, fruits from the former usually show a considerably higher (wet-basis) fat content. Stahl has observed, however, that the dry-basis determinations show approximately similar fat-contents. As noted in the preceding section, this factor also enters into the comparison of varieties grown under Californian, Florida and West Indian conditions, the water relation being of fundamental importance.

Some preliminary growth curves for Californian fruits have been published by Marsh (21). These are of the usual sigmoid type, higher growth rates having been recorded during years of light crop.

* Three avocado races are generally recognised: the Mexican, the Guatemalan and the West Indian (10).

IV. Chemical Composition of the Seed.

Whereas the principal storage material of the edible pulp is fat, that of the seed is starch, present to the extent of 29.6 per cent. (37).

Percentage Composition of Californian Avocado Seed—Wet Basis (after Weatherby).

Water	50.4
Ash	1.3
Protein	2.5
Reducing sugars	1.6
Sucrose	0.6
Starch	29.6
Pentosans	1.6
Arabinose	2.0
Ether extract	1.0
Fibre	3.7
Undetermined (including perseit)	5.6

The avocado seed is the best known source of the rare substance perseit, a solid alcohol containing "seven hydroxal groups."

V. Physiological Diseases—Their Relation to Growth and Water Economy.

Two types of physiological disease are known to occur in developing or mature fruits under Californian conditions: end-spots, in which the larger or stylar end gradually withers, dries and cracks, so that in some instances the seed may be exposed, have been described by Coit (4A) as affecting mature fruits of thin-skinned varieties on the tree; "speckles", another type of end-spotting, consists of small, dark, dry and depressed spots on the skin. According to Horne (16) the factors involved include over maturity of the skin in the affected portion, and desiccation of the fruit surface as a result of an extreme water deficit. Haas (10A) has expressed the view that end-spots may become of increasing importance because of the growing preference for thin-skinned varieties of avocado.

In a detailed investigation Haas has shown that in the developing avocado, the greatest amount of growth, and, in consequence, the widest spacing of the stomata, occur from the stem-end to the region of largest diameter, the region of least growth and closest spacing of stomata being towards the tip or stylar end. The bearing of stomatal distribution on gaseous exchange (carbon dioxide and oxygen) and on transpiration in different regions of the fruit is of considerable importance. Haas has shown that (*a*) the skin is more permeable and has a higher transpiration rate at the distal than at the stem-end and (*b*) reduction in gaseous exchange results in serious damage to the skin and pulp, especially at the distal end.

As fruits approach maturity, the stomata gradually function less efficiently, necrosis of the guard cells and surrounding cells being of common occurrence. As a result, protection against desiccation is diminished and the disease known as speckles may result. These areas also become important in relation to the invasion of pathogens. In thin-skinned varieties, such as the Fuerte, the disorganised stomata are not replaced by lenticels, but in thick-skinned varieties there is active cork formation and well-developed lenticels are the rule.

By smearing fruits, still on the tree, with a paraffin of low melting point, Haas showed that the reduction of gaseous interchange was accompanied by serious injury to the skin and pulp. From his observations he makes the suggestion that the tendency of the fruits of certain varieties to darken internally with advanced maturity may be related to inadequate gaseous exchange. Again by immersing fruits in distilled water, thereby restricting the movement of gases, he showed that characteristic injuries could be induced in the stomata and also at the distal end where the carpellary fusion tissue is weak. "The water apparently can penetrate the weak fusion tissue of the carpellary structure rather rapidly and then diffuse laterally after absorbing or pushing aside the bubble of air from the depression at the tip end. In penetrating at this point the water kills the tissue, the by-products of which are then free to kill or injure the adjacent tissue."

In certain varieties, the disease known as end-spotting involving premature colouring, drying, shrinking and cracking of the tissues at the distal end, may be induced in fruits at various stages of development by prolonged drought conditions.

The fusion tissue situated below the style, as well as absorbing water rapidly, also dries out rapidly under conditions of restricted water supply, thus accounting for the disease symptoms observed.

By immersing fruits in distilled water injuries may also be induced in certain thick-skinned varieties. The types of water injury produced in the laboratory may also occur in the field during periods of rain and foggy weather. Thick-skinned varieties growing in soil kept very wet over a long period as a result of heavy rains may absciss in large numbers. Haas suggests that such abscission may be a result of injury to the young (absorbing) roots consequent on the reduction of oxygen in the soil.

VI. Picking Maturity.

Though avocados intended for storage are picked in a firm and inedible condition, their maturity must be such as to permit of normal ripening, *i.e.*, softening with the full development of the characteristic consistency and palatability. Fruits picked before this stage of maturity has been reached behave abnormally: they fail to soften, and acquire a leathery consistency, dark flesh and undesirable flavour. Fruit which has become almost ripe on the tree, on the other hand, will only remain in good condition during a relatively brief storage period. In many

instances the physical appearance of the fruit gives little indication of its maturity. The maturity problem is therefore one of special importance, calling for a knowledge of the changing composition of the fruit throughout its development.

VII.—Maturity as determined by Fat Content and Specific Gravity.

In a considerable series of analyses, Stahl (30) has shown that the amount of moisture varies inversely with the amount of fat: the highest moisture content is to be observed during the early growth phase of the fruit, whereas the increasing fat content is associated with the onset of maturity. As has been indicated, the percentage moisture in the pulp itself varies with climatic conditions.

In developing fruits the fat content is at first low, one to two per cent. on the wet basis; this is followed by a rapid and uniform increase up to a certain point, after which the rate of increase falls off. When the fat content has reached its maximum, the fruit is quite mature and on being harvested will soften and develop its full, normal flavour. Accompanying these important changes in fat and moisture content in developing and ripening fruits, the specific gravity undergoes marked changes, from values above 1 for immature fruits to values of 1-0.90 for more mature or ripe fruits. In some varieties, fruits with a specific gravity of 0.80 at the time of picking have been encountered.

A definite correlation between specific gravity and fat content has been demonstrated by Stahl (30), the accumulation of fat in maturing fruits being invariably accompanied by a decrease in specific gravity of the whole fruit, even though other factors, *e.g.*, variable moisture content, the increasing specific gravity of the stone in maturing fruits, or the development of a seed cavity, are also involved. This relationship between fat content, maturity and specific gravity would appear to afford a simple test for determining the earliest stage at which fruits may be picked with the assurance that normal ripening will follow. Specific gravities of 0.98 and 0.96 have been shown to be critical for a number of Florida varieties. In an earlier investigation Church and Chace (14) were unable to demonstrate this correlation using Californian fruit.

VII. Oil Content by Refraction Methods.

As a quick means of determining the oil content of avocado pulp, refraction methods have been attempted but with little success. Among other sources of error it has been observed that considerable differences in refractive index are encountered in the oil from different varieties. In any one variety the refractive index has also been found to vary according to the method of extraction employed (20, 30).

IX. Picking Maturity and Time to Ripen.

So far, especially with green varieties, it has been impossible to correlate closely any character or set of characters, based on *external appearances*, with the maturity of the fruit. The time that elapses between picking and softening to "eating-ripeness" affords a rough indication of the maturity of the fruit and its suitability for marketing. As the season advances and fruits become mature on the tree, this period diminishes rapidly. Analyses show that this change is not, or only occasionally, associated with the fat-content, other factors, as yet uninvestigated, being involved.

Using seedling avocados grown in Trinidad, Wardlaw (33) and Wardlaw and Leonard (34), have shown that if colouring varieties are picked when they show the first traces of colour, the following rates of ripening in relation to temperature of storage may be expected.

Rate of Ripening (after Wardlaw and Leonard).

Temperature °F.	*No. of days to ripen.*
80	3-6
70	6-12
60	7-15
53	12-22
45	20-32
40	30-40

X. Critical Storage Temperatures.

Dybowski (8) writing in 1902, stated that with shipments of avocados from the Antilles to France, a temperature of 2°C. (35.6°F.) was the most satisfactory. According to Condit (5, 6), Mexican avocado varieties, cultivated in California, kept well for one month in cold storage but subsequently deteriorated through shrivelling and decay. The Challenge variety is stated to have stored satisfactorily at 32°F. for six weeks. More recent investigators, however, have placed the optimum storage temperature at 40°F., 45°F. or 50°F. Thus Overholser (24) in storage experiments with Californian avocados, found that a temperature of 40°F. was satisfactory for all varieties tested except the Fuerte which required 45°F. to prevent blackening of the skin. Overholser considered a temperature of 32°F. too low as it led to a discolouration of the flesh, though he did obtain indications that some varieties might be stored satisfactorily at 32° to 35.6°F.; under favourable conditions storage could be prolonged for periods of five to eight weeks.

As early as 1907 Higgins (13) in Honolulu referred to the successful export in refrigerated chambers (temperature not specified), of avocados from Hawaii to San Francisco (approximately seven days) with subsequent distribution by rail. In 1911 Higgins, Hunn and Holt (14) ascertained that prolonged storage at 0-2°C. (32°-35.6°F.) resulted in the blackening of the interior of the

fruits; this injury, however, did not appear during the first three to four weeks of storage. Harold (12) states that Hawaiian avocados may be stored green at 36°F. for six to eight weeks, thereafter ripening satisfactorily in two to five days, while Wilcox (40) has reported that Hawaiian fruits were held at 32°F. for two months without injury. In the modern practice in California (15), stored fruit is held at a temperature of 40° to 45°F.

In the West Indies (33, 34), in the course of experiments with a large number of local seedling varieties, it was found that only a few varieties could be held at a temperature of 45°F. for 20 to 25 days without sustaining low temperature injury.

During cold storage, even at relatively low temperatures, maturation processes slowly continue so that fruits ultimately become ripe and finally over-ripe. In the few West Indian varieties which are sufficiently cold-resistant or tolerant of low temperatures, such ripening apparently takes place in a more or less normal manner, the flesh at maturity being of good flavour and free from internal breakdown, discolouration or other obvious abnormalities (34). On the other hand, in the majority of West Indian varieties which do not possess adequate cold resistance, maturation processes also continue but it is evident that the metabolic trend is abnormal. Thus although such fruits eventually become soft in cold storage, inspection of the flesh at once shows that chill effects have been induced. The range in genetical constitution of West Indian seedling varieties is strikingly exemplified in the matter of cold-resistance: this extends from varieties subject to chilling after 15 days at 53°F. to those which ripen normally during 40 days at 40°F.

XI. Changes during Storage.

During storage at ordinary temperatures avocados show an increase in fat—approximately two per cent. of fresh weight has been consistently observed (30)—and hydrolysable sugar content, and a decrease in moisture, free reducing and total sugars. The increase in fat content is particularly noticeable when relatively immature fruits are stored (4). Stahl considers that the increases in fat content are not entirely due to water loss by transpiration, since the increases are also observed when the data are stated on a water-free basis.

Wolfe, Toy and Stahl (41) note that, unlike some fruits, the avocado remains in perfect condition on the tree for some time after reaching normal picking maturity. In some instances a few fruits may hang for months without becoming soft enough to eat. On the other hand, in full-bearing trees, the dropping of the first sound fruits, when approximately full-grown, is usually accepted as an indication that the fruit is mature.

XII. Self Heating in Packs.

The tendency of avocados in storage to develop heat in the packs and in consequence to ripen prematurely has been commented on by various workers. For the same reason the use of wraps and overtight packing with excelsior, wood-wool or other similar materials should be avoided. As avocados may ripen fairly quickly even at a storage temperature of 50°F., it is important that rapid cooling should be achieved and that the tendency to self-heating be counteracted by an adequate circulation of cold air.

In experiments conducted by Wardlaw (33), it was found that with rapidly circulating room air at a temperature of 45°F. the flesh temperature of fruit in fully exposed single crates was not reduced to the temperature of the room in the course of six days, a steady difference of approximately 2°F. being maintained. In another experiment in which 24 crates of fruit were placed together so as to form a solid block, still larger differences between the temperatures of delivery air and fruit flesh were noted. From these observations it was deduced that where large consignments are being handled, a temperature difference of 5°F. might be encountered between the delivery air and the fruit flesh in the inside crates, with concomitant depreciation through wastage and premature ripening.

XIII. Low Temperature Injury under Field Conditions.

In California, varieties differ widely in the degree to which they can withstand low temperatures under field conditions (26). Susceptibility to injury is a genetical character and may be operative in respect of the tree itself, the blossom or the fruit.

Because of its high oil content the avocado does not readily freeze, but, in areas subject to frost, heavy losses may occur through the freezing and subsequent breaking of the fruit stem (16). This aspect of wastage may to a considerable extent be eliminated by propagating varieties which bloom after the frost and mature their crops in eight to ten months.

There is a marked difference in frost resistance among the three races of avocado, the West Indian race being less tolerant of low temperatures than the others. It has been shown that the cell-sap of West Indian varieties freezes at a higher temperature than do those of the Mexican or Guatemalan varieties, and that the Guatemalan has a higher freezing point than the Mexican (11). Because of their tolerance of low temperatures, Mexican varieties may eventually play an important part in the development of commercial types.

Hodgson's (15) account of frost injury to fruit on the tree is as follows: "When the fruit itself is affected the first indication is usually the development of a reddish-brown color; the thinner-skinned varieties sometimes exhibit brownish-black spots. The first internal indication of frost injury is darkening of the fibers in the flesh, which usually turn black. The flesh may also turn gray in color and if badly frozen it fails to soften".

XIV. Low Temperature Injury during Storage.

The possibility of developing an export industry in avocados in countries where delicate varieties intolerant of low temperatures are cultivated, largely rests on the question of cold resistance. In varieties possessing adequate cold-resistance the flesh which has matured during storage is of normal appearance and good flavour. In others, ripening is accompanied by abnormal changes, and with the softening of the flesh various chill effects, including loss of flavour, become more or less conspicuous. The incidence of chilling is largely linked with the maturity of the fruit and the storage temperature employed (34).

Chilling may be defined as the response to, or the effect produced by, excessively low temperatures in ripening fruits. In its final stages it may lead to a definite breakdown or necrosis of tissues. In varieties subject to chilling at 45°F. evidence of low temperature injury may be observed at an early stage, the flesh becoming discoloured while fruits are still hard and unripe: despite the presence of this pathological condition, however, such fruits continue to ripen, and ultimately become quite soft, with further accentuation of the internal discolouration. Short of killing tissues outright by freezing, therefore, it may be inferred that vital processes are involved both during the initiation and subsequent development of chill effects.

Various manifestations of chilling have been observed in fruit exposed to air-blast refrigeration (34):

1. In some varieties the skin becomes more or less severely necrosed, frequently in proximity to the stem-end, or brown, circular or confluent blemished areas may be distributed generally over the skin. As such areas develop at temperatures below the minimum for growth of the common storage pathogens, and as fungi could not be isolated from them, the symptoms described can safely be referred to chilling, possible accentuated by desiccation. Skin-necrosis, however, is not usual, the large number of varieties showing internal chill effects remaining normal as regards external appearance.

2. Internal chill effects are easily observed. While still firm, the flesh on cutting is seen to have acquired a slightly dark, smoky or brownish discolouration (14, 33, 34). In some varieties this is chiefly located next the stone, in others it may occur in the tissue mid-way between stone and skin. In some instances the incipient chill symptoms may take the form of linear areas as seen in longitudinal section, in others as isolated circular patches distributed towards the middle and distal regions of the fruit. Chilling of the flesh becomes accentuated with the onset of final maturity and culminates in a more or less general discolouration of the entire tissue to a smoky brown, chocolate-brown or black appearance. Low temperature injury has also been described as giving the flesh a greyish appearance. In Californian avocados, Horne (16) has described a darkening of the flesh sometimes associated with frost injury (see previous section) but in other instances due to other causes as yet uninvestigated.

3. In some varieties, either in conjunction with, or in the absence of discolouration of the flesh, the vascular strands which run longitudinally through the fruit may lose their clear, inconspicuous hyaline character and acquire a characteristic brown or blackish necrosed appearance by which they are rendered very conspicuous.

4. In occasional instances chill effects may also extend to the stone: in the hard, fleshy cotyledons, abnormal brown areas may be observed on sectioning.

5. In the matter of flavour, various changes are associated with chilling: in some varieties palatability is only slightly impaired, whereas in others the nutty quality of the normally ripened fruit may be replaced by a pasty, insipid flavour, or more or less acrid flavours may be produced.

Chilling in avocados is a complicated phenomenon in which various factors are involved. Among others the temperature and duration of storage are important: some varieties ripen normally after 20 days at 45°F. on removal to a higher temperature, whereas if held at 45°F. for an additional ten days chill effects develop. The maturity of fruit at the time of storage is also of critical importance: fruits stored immature only show chill effects after long exposure to the low temperature, *i.e.*, after a certain stage in ripeness has slowly been reached, whereas fruits of the same variety stored more mature may show chill effects in a relatively short time. In general, the evidence available indicates that fruits are most subject to chilling during the initiation of ripening.

XV. Respiration and Gas Storage.

Respiration studies with the Fuerte variety were made by Overholser (25) at 19° to 22.3°C. (66° to 72°F.), 7.1° to 8.1°C. (44.6° to 46.5°F.) and 0.0° to 0.1°C. (32.0° to 32.2°F.). The experimental method employed, however, was such as to make for gas storage conditions (*e.g.*, the CO_2 of respiration was allowed

to accumulate in the containing vessel, concentrations of 6 to 12 per cent. being recorded in some instances with corresponding reductions in the concentration of oxygen) and the normal trend of respiration during ripening and senescence was therefore modified. Overholser himself observed that fruits within the containers remained firm longer and had a longer storage life than control specimens exposed in open baskets. At an average temperature of 21.1°C. (70°F.) the respiration rate, under the conditions of the experiment, declined from 100.1 mg. per kg. per hour to 50.0 mg. per kg. per hour in the course of 12 to 13 days; at 7.4°C. (45.3°F.) the respiration rate remained at approximately 19 mg. per kg. per hour over a period of 31 days; at 0°C. (32°F.) the respiration rate declined from 8.8 to 1.9 mg. per kg. per hour, during a storage period of 62 days. It would appear that once the Fuerte avocado is held at or below the chilling temperature (*i.e.* below 45°F.) the effect of temperature on reducing the rate of respiration becomes very marked.

In preliminary respiration studies at 70°F., using freshly picked, full-grown but firm fruits, Wardlaw and Leonard (34) observed that there is a rapid rise in the output of CO_2 after two to four days. Thereafter the amount steadily decreases over a period of eight to 14 days at the end of which time fruits become over-ripe and are more or less completely killed by the inroads of fungi. The data show that the climacteric rise to the peak value is not correlated with the development of colour in colouring varieties or with the softening of fruits in general, these manifestations of ripening being definitely of later occurrence.

Respiration rates at 70°F. were as follows: 40 mg. kg. hr. for preclimacteric fruit, rising to 170 mg. kg. hr. at the climacteric peak (34).

In experiments undertaken in Trinidad (33, 34), some evidence was obtained that avocados would probably lend themselves to preservation by a combination of refrigeration and gas storage. Collectively the data from gas-storage experiments show that by using subnormal concentrations of oxygen alone, or in conjunction with high concentrations of CO_2, a definite decrease in the rate of maturation can be induced. The range of tolerance to such treatments, however, varies from variety to variety, being comparable though not necessarily parallel to the response of different varieties to low temperatures. In varieties unsuited to gas-storage, external and internal damage may be sustained without the intervention of micro-organisms. In other varieties, although no direct physiological injury may be apparent, the fruits subsequently prove much more susceptible to the inroads of storage pathogens. Others, again, show surprising tolerance of gas-storage conditions and would undoubtedly lend themselves to commercial preservation by this method. It is interesting to note that in this category are varieties subject to chilling and consequently unsuitable for transport at low temperatures.

Overholser (23) also has indicated the possibility of employing gas-storage methods in the preservation of Californian avocados. Thus *Fuerte* avocados which could only be held for ten days at 70° to 80°F., and for one month at 45°F., could be kept in good condition for two months at 45°F., provided fruits were maintained in an atmosphere of four to five per cent. oxygen and not more than four to five per cent. CO_2. Furthermore he observed that excessive concentrations of CO_2 did not result in the production of objectionable flavours, but prevented softening of the flesh, so that it remained tough even after removal.

The possibility of achieving preservation, on the principle of gas-storage, by the application of suitable smears and wraps has also been considered (34). It was found that smearing with such substances as vaseline, vaseline *plus* beeswax, vaseline *plus* cacao butter, paraffin wax in liquid paraffin, liquid paraffin, vaseline *plus* linseed oil, exercised too great a restriction on gaseous interchange, *i.e.*, access of O_2 and escape of CO_2, and whereas untreated control samples coloured and ripened normally in the course of 5 to 6 days at 70°F., treated fruits remained green and firm, failed to colour or ripen normally in the course of 14 to 16 days, and developed skin blemishes of physiological origin. Provided a smearing substance possessing a suitable partial permeability to CO_2 and O_2 could be used in conjunction with moderate refrigeration, it is not impossible that certain varieties of avocado might be handled by this method.

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THE BANANA LEAF SPECKLE IN SURINAM CAUSED BY *CHLORIDIUM MUSAE* NOV. SPEC. AND ANOTHER RELATED BANANA DISEASE.

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Fungal leaf diseases are very troublesome to bananas in Surinam and in particular to the Congo banana which is more susceptible to them than the Gros Michel. The latter variety, however, cannot be planted on a commercial scale on the acid Surinam clay soils owing to the ravages of Panama Disease. Usually, on plantations along the rivers only one good crop of bananas can be harvested. When, however, the bananas are sprayed twice a year with Bordeaux Mixture as is done on the experiment fields of the banana consortium of the "Ondernemers Raad voor Suriname" several crops can be ripened.

Leafspot, caused by *Cercospora musae* is at the present time the most widely spread disease. *Helminthosporium torulosum* and *Cordana musae* are also prevalent but in certain localities only. Another disease, described in detail in this paper, is the banana leaf speckle and although not as serious as the others it must be regarded as capable of considerably reducing the effectiveness of banana leaves on which it occurs.

Occurrence.

The occurrence of banana leaf speckle is greatly influenced by the humidity of the surrounding air, whereas that of *Cercospora*, *Helminthosporium* and *Cordana* depends on a prolonged covering by dew.

Speckle is prevalent under shade trees and along the humid edges of the jungle where often every leaf up to the third or even the second may show speckles; these, in turn, gradually become bigger and often cover practically the whole surface of the older leaves. In open fields under less humid conditions *Cercospora*, *Helminthosporium* and *Cordana* are predominant and speckle is found only on the oldest, shaded leaves.

According to Wardlaw (3) speckling is very frequent in Trinidad and is found elsewhere in the West Indies. In 1933 Simmonds (2) described a leaf speckle of bananas in Queensland, Australia. His photographic reproduction of a speckled leaf shows some resemblance with the Surinam disease, especially with the second type of speckle, described at the end of this paper but before a conclusive mycological investigation is made, it will be impossible to decide whether the Australian and even the West Indian disease is identical with the Surinam speckle.

External Symptoms of the Disease.

In order to understand the nature of typical speckling, reference must be made to the anatomical structure of the parallel-veined banana leaf (Figs. 7 and 8).

The venation of the leaf of the Congo banana is such that every 20th or 30th vein is considerably larger than its neighbours, and includes a strong development of sclerenchyma, especially below the upper epidermis. The average distance between the veins is a little less than a quarter of a millimeter. Below the epidermis there is a layer of big water cells while on the upper side of the leaf there are sometimes two. The palisade parenchyma consists of three layers of palisade cells and one layer of collecting cells. On the lower side of the leaf there are one to two layers of a loose mesophyll. There is also a large air space bounded by the vascular bundles, the palisade tissue and the mesophyll. This space however does not form a channel running parallel to the vascular bundles but is divided, at an average distance of about 180μ, into sections by cross walls consisting generally of one layer of big rectangular cells without intercellular spaces. About every fourth cross wall is much thicker on the side of the palisade tissue and contains a small vascular bundle (Fig. 8). These anastomoses are able to feed the parts of a leaf that are deprived from direct vascular communication by leaf spots caused by *Cercospora* and *Cordana*. If the *Cordana* lesions enlarge or if the small *Cercospora* spots coalesce to form large dead patches, the anastomoses are no longer able to feed the broad distal parts of the leaf which thus dry out and die.

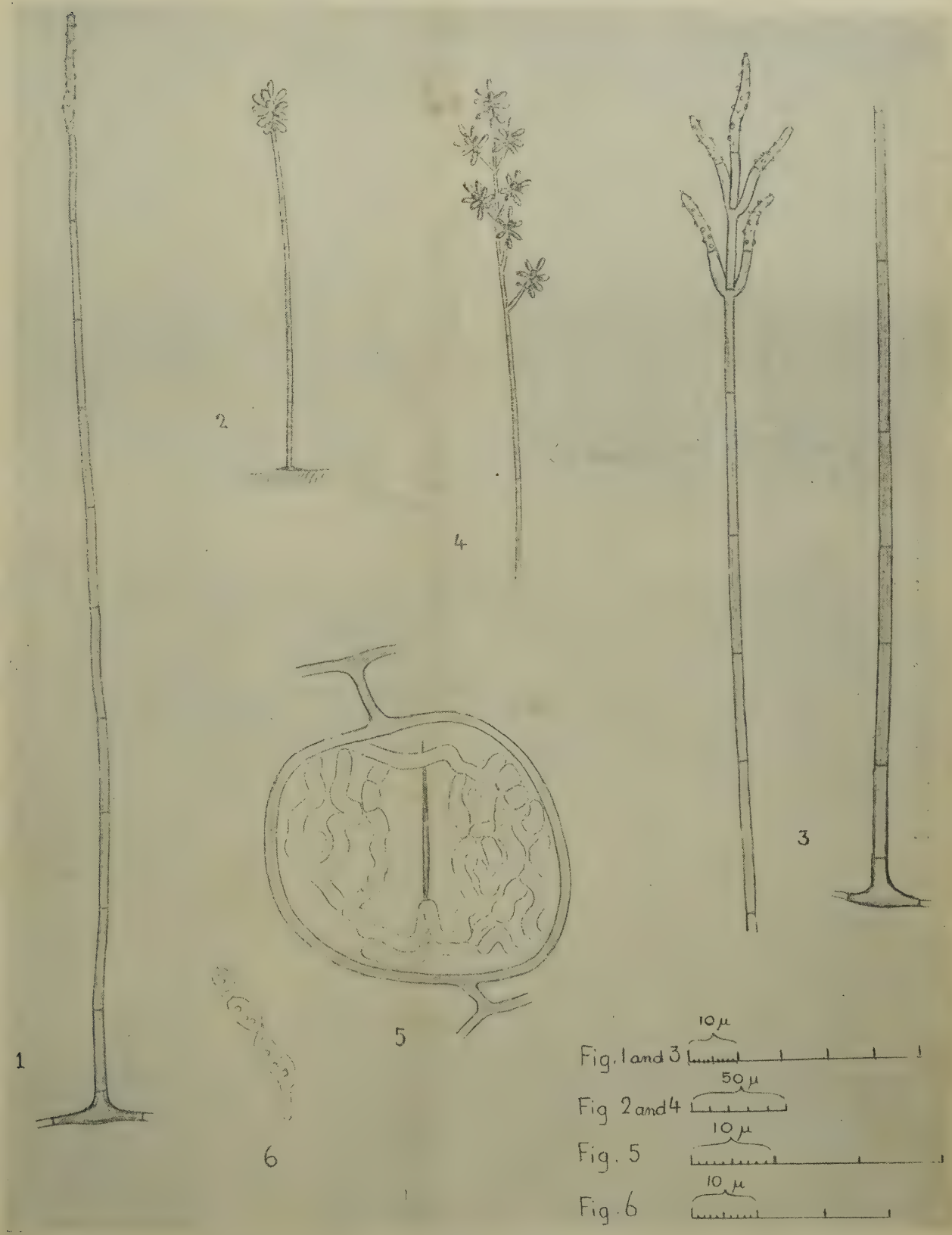
On every square millimeter of a banana leaf there are about 16 to 20 air chambers each of which communicates on the abaxial side with seven to eight stomata.

The speckled spots and larger patches are formed by a great number of isolated minute black or brown speckles in an otherwise green part of the leaf. With a magnifying glass it can easily be seen that every speckle is identical with an air space (Fig. 15). In the small spots on younger leaves five to ten per cent. of the chambers are blackened, in bigger patches on older leaves 30 to 40 per cent. and in the large areas on the oldest leaves as much as 60 per cent. The speckles are visible on both sides of the leaf, but are more conspicuous on the upper side (Figs. 13 and 14).

Even in the speckled areas of the older leaves the vascular bundles are still functioning. The only damage caused by the common Surinam leaf speckle thus consists in the removal of a part of the assimilating tissue. On leaves covered entirely with big coalescent speckled patches, the reduction in the assimilating power must be considerable.

The speckled spots enlarge gradually. It is hardly likely that these spots are caused by a parasitic agent spreading inside the leaf, but if the parasite is growing on the surface it is easy to understand why only part of the air chambers is infected.

BANANA LEAF SPECKLE IN SURINAM.



For Captions see Text.

BANANA LEAF SPECKLE IN SURINAM.

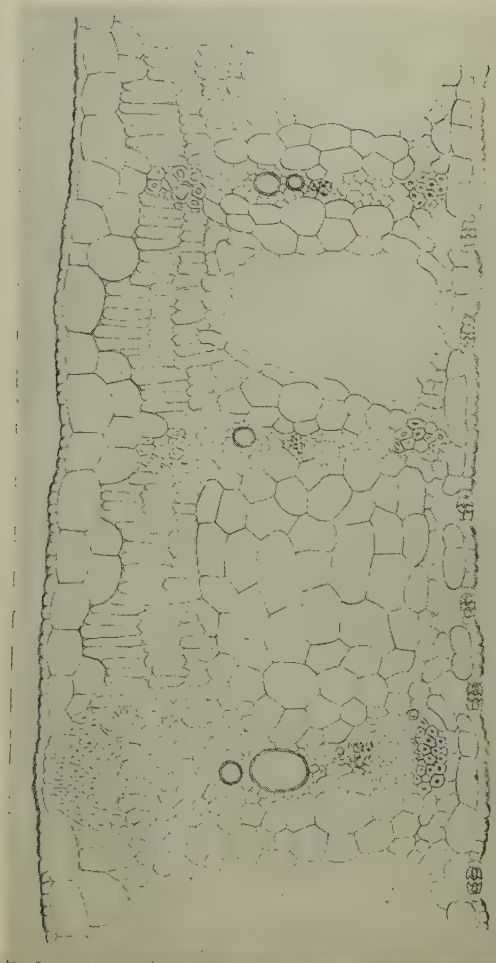


Fig. 7

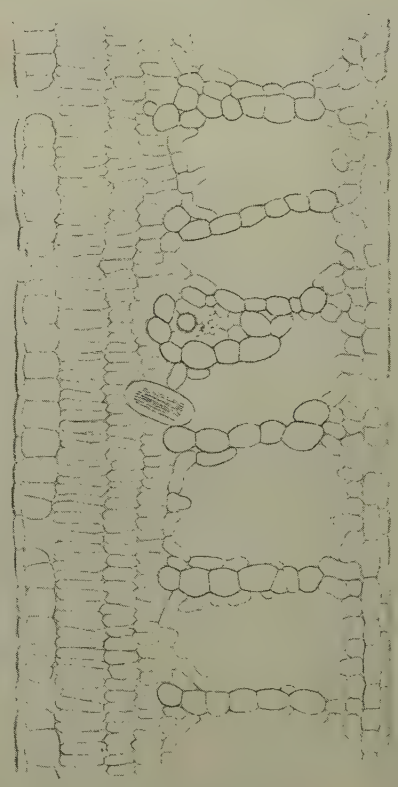


Fig. 8.

For Captions see Text.

BANANA LEAF SPECKLE IN SURINAM.

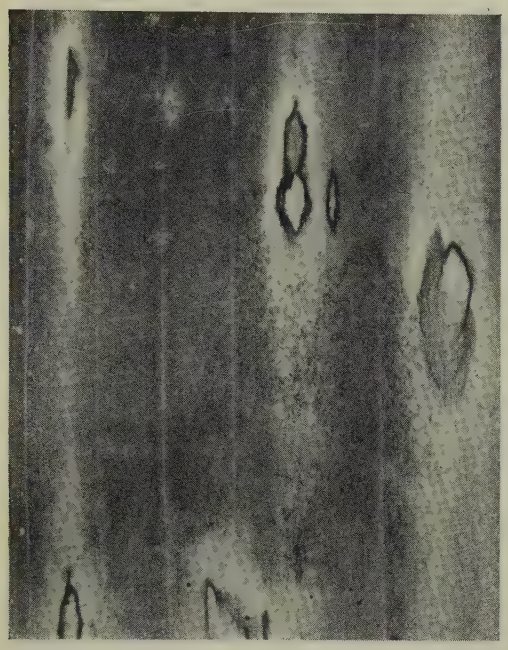


FIG. 13.

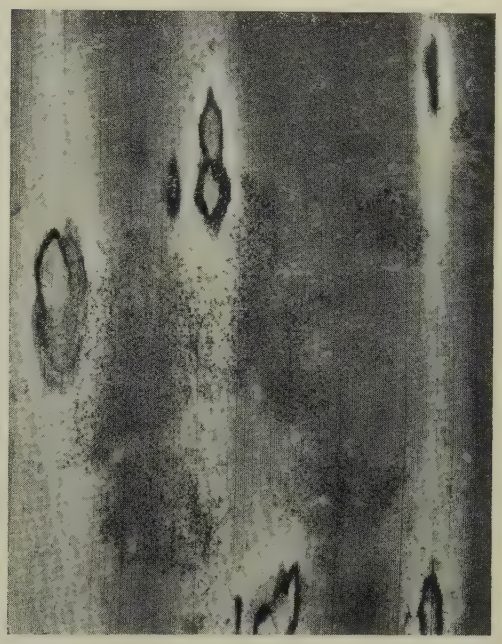


FIG. 14.

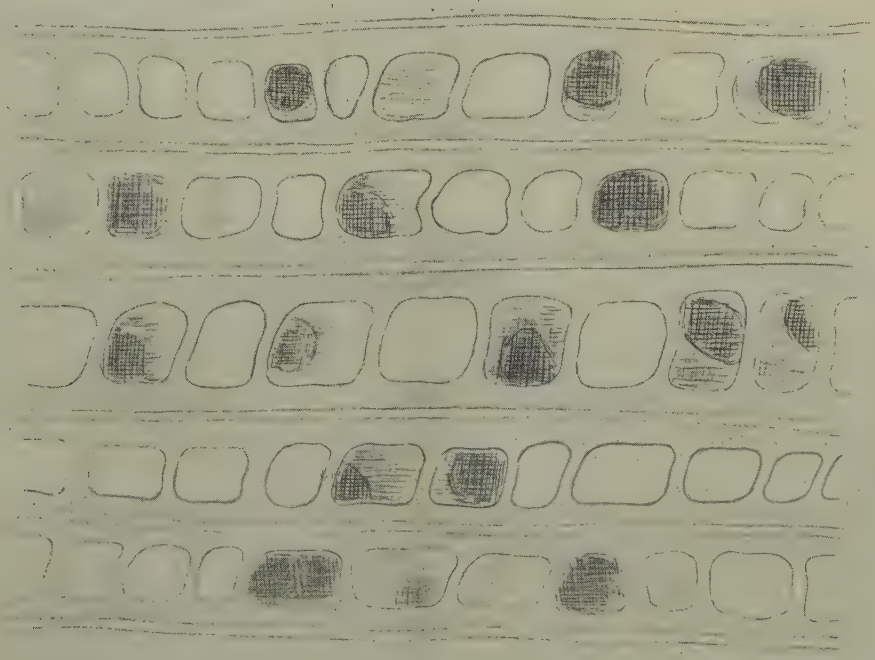


Fig 15

For Captions see Text.

BANANA LEAF SPECKLE IN SURINAM.

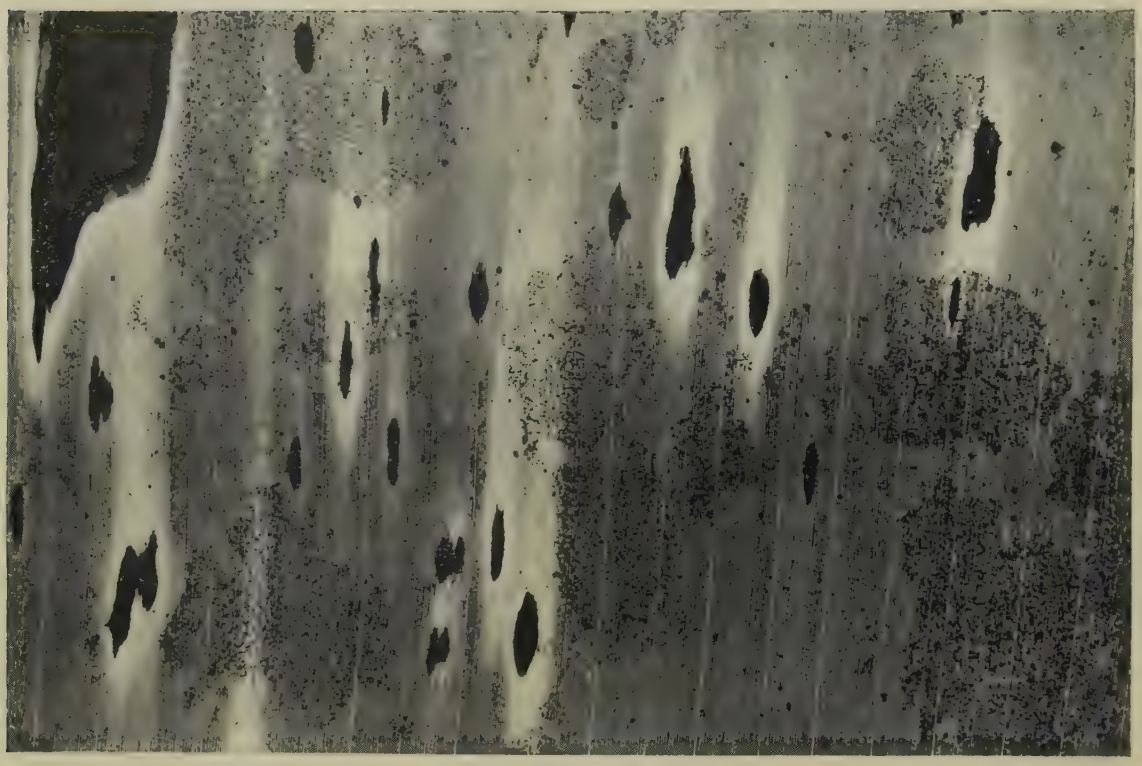


FIG. 16.

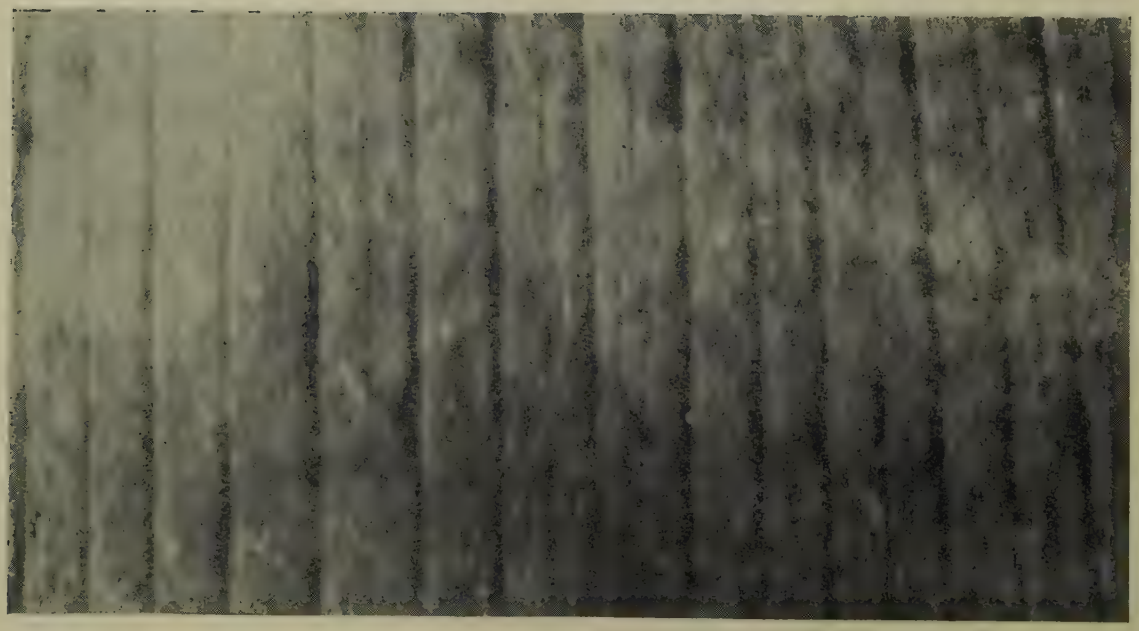


FIG. 17.

For Captions see Text.

The Causal Fungus, *Chloridium Musae*, Nov. Spec.

When a piece of banana leaf with a speckled patch is bent so that the lower surface is on the convex side, it is easy to see, even with the naked eye, that the patch is covered with fine rigid hairs; while the upper surface is smooth.

Scrapings of the lower surface of such a patch show under the microscope a practically pure collection of the conidiophores of a fungus belonging to the genus *Chloridium*. No conidiophores are found on the upper surface. Moreover a tangential section of the lower epidermis of a speckled patch reveals that the leaf surface is covered with conidiophores, 66 conidiophores being counted per square millimeter on a typical spot.

The conidiophores arise from hyphae, 1 to 2μ thick, which form a very loose, cobweb-like epiphyllic mycelium that is attached to the leaf surface by the bases of the conidiophores and by stomatopodia.

The initiation of a conidiophore consists of a local swelling on an epiphyllic hypha, which is coloured dark brown. From this swelling the conidiophore arises. The T-shaped base is attached to the cuticle. In tangential sections of the epidermis some conidiophores are broken just above the basal part, but in most cases the conidiophores are pressed down as a whole, the connection between the base and the cuticule being broken.

The stomatopodia are side branches of the epiphyllic mycelium formed exclusively above the stomata. They are club-shaped and of a darker brown colour than the other mycelium (Figs. 10 and 11). In a typical spot every sixth stoma was found to be covered with a stomatopodium. From the latter an infection tube passes through the stoma into the leaf. This infection tube is a thick, rigid, warty, light brown hypha 3 to 3½μ in diameter, which grows without branching through the lumen of the airchamber to the palisade tissue. Here the tube branches, sending side branches into the palisade parenchyma (Fig. 9).

After some time the palisade tissue is killed and discoloured dark brown or black. The fungus cannot spread to the neighbouring chambers. The discolouration therefore is confined to the chambers that are infected from the epiphyllic mycelium (Fig. 15).

If a piece of speckled tissue heated in glycerine and brought under the microscope, the lower epidermis uppermost, it can easily be seen that some of the chambers which are still green contain one or two stomata covered with stomatopodia. It was not ascertained whether they formed any infection tubes, or whether the tubes were present but had not reached the palisade tissue, or possibly whether the palisade parenchyma had not succumbed to the attack of the fungus.

The conidiophores are 100 to 300μ long and of a dark brown colour. In the lower part they are about 2μ thick, but near the end only 1½μ. The terminal part of the conidiophore is hyaline, 20 to 30μ long, and covered with minute projections on which the conidia are formed. This part is slightly thicker than the adjoining part of the conidiophore (Fig. 1).

The conidia of the genus *Chloridium* are described as pleurogenous. In water, in alcohol or even in a strong gelatine solution, the ripe conidia are invariably dislodged from minute bubble-like sterigmata. Often, however, a small, very young conidium is found attached to the end of the conidiophore, never to the sides, exactly as described by Lindau with *Chloridium minutisporum* (1).

It is very easy to observe even the oldest conidia *in situ*, by cutting out a strip about 1 mm. broad of a speckled spot and placing it carefully on a dry slide, so that it stands on one of the freshly cut sides.

It was found that the conidia cover the entire terminal part of the conidiophore (Fig. 2). The conidia start exclusively at the terminal point, which grows further forming new conidia that ripen gradually on the sides. The term pleurogenous has therefore to be used with some restriction.

The conidia measure 6 to 7½μ by 2½ to 3μ (extremes 5 to 8μ by 2 to 3½μ). They are hyaline and oval or egg-shaped. On the smaller end, which was formerly attached to the conidiophore, there is a minute papilla.

On a microculture slide many of the conidia germinate in water in 12 hours producing a hyaline appressorium 4μ broad and 10 to 20μ long at the terminal end, a hypha 1 to 1½μ thick (Fig. 6). If a suspension of conidia in distilled water is sprayed in the field on the lower surface of a banana leaf, many of the conidia appear to germinate after 24 hours, the fine hyphae creeping over the leaf surface. When these hyphae are traced back to the conidia, typical appressoria are found as described above.

If a small part of the mycelium from an agar culture is brought in a moist glass chamber (Petri dish) to the lower surface of a banana leaf, the fungus spreads in a few days over the leaf forming conidiophores and a few stomatopodia.

The infection experiments in the field however were not very conclusive, and will be repeated later in a glasshouse, to be built for the study of the banana leaf diseases and where it will be possible to control moisture factors.

Culture of the Fungus.

The isolation of the fungus in Petri dishes is very easy. The conidiophores are so long, that the conidia can be picked up under the binocular microscope with a platinum needle in most cases without contamination. Most of the plates

showed only the mycelium of *Chloridium*. The fungus grows fairly quickly, the colonies being visible after two days.

Chloridium grows well on acid nutrient agar such as on banana—, prune—, or Sabourauds agar. On carrot, growth is luxuriant.

The colour of the mycelium is a dark olive green. Fairly typical conidiophores are formed and the production of normal conidia is abundant.

On banana agar the mycelium forms four to six mm. long pointed rigid rhizomorphs, which grow straight into the air. These rhizomorphic spines are covered all over with typical *Chloridium* conidiophores.

Several times the conidiophores were found to have grown out at the ends of hyphae showing short side-branches which produced acrogenous solitary conidia like *Acremonium*.

Agar cultures of this *Chloridium* have been sent to the "Centraal Bureau voor Schimmelcultures" in Baarn, Holland, whence cultures of this fungus may be obtained for comparison.

The causal fungus is thus a typical leaf ectoparasite. It is fed by parasitic hyphae, which grow through the stomata of the lower leaf surface to the palisade tissue, which dies and becomes discoloured. Not all the air-chambers are discoloured, so that the infected leaves have a speckled appearance. The vascular bundles are not destroyed.

This species of *Chloridium* is a typical parasite of the banana in Surinam and has not hitherto been described. The name *Chloridium musae* nov. spec. is proposed.

Control.

Leaf speckle can be efficiently controlled by spraying with Bordeaux Mixture. This is proved clearly in the regularly sprayed fields of the banana consortium of the "Ondernemersraad voor Suriname". In the experimental field on the Katwijk plantation there is practically no *Chloridium* in the sprayed plots, whereas in the untreated ones much speckling occurs.

Leaf Speckle Caused by *Ramichloridium Musae* Nov. Gen., Nov. Spec.

Hitherto this leaf speckle has been found only on Pisang Radja on sandy soil in the "Cultuurtuin" in Paramaribo, where several plants are badly infected by this diesase. This speckle is not as conspicuous as that caused by *Chloridium* and might be overlooked elsewhere.

Except on the oldest leaves, the spots are visible only on the lower surface, where they appear as velvety, greyish to brownish coverings (Fig. 17). On the oldest leaves the spots can also be seen on the upper side of the leaf as light green spots. These leaves are slightly bent, the lower surface being concave.

The causal fungus closely resembles *Chloridium*; being in fact a ramified *Chloridium* with short branches standing opposite or singly, never verticillate. Its biology is also similar (Figs. 3 and 4).

The conidiophores are 200 to 500μ long, about 3μ thick at the base, but only 2μ near the end. The number of conidiophores is much greater than with *Chloridium*, about 400 per square millimeter. With a razor the conidiophores can be shaved from the leaf in a felt-like layer. The conidia are of the same length as those of *Chloridium* but somewhat narrower, $1\frac{1}{2}$ to $2\frac{1}{2}\mu$. They are produced exactly in the same manner as those of *Chloridium*.

The epiphyllic mycelium has smaller, thinner hyphae (1μ in diameter) of a light brown colour. The stomatopodia are smaller, but otherwise similar (Fig. 12). They are much more numerous, as many as 80 per cent. of the stomata having stomatopodia. The parasitic hyphae are hyaline, warty and 2 to $2\frac{1}{2}\mu$ thick. The close covering of the inside surface of the invaded stoma by a layer of fine, heavily wrinkled, hyaline hyphae (Fig. 5) is typical of *Ramichloridium*. From this layer several hyphae start to grow through the lumen or along the walls of the air chamber. They can branch again before they reach the palisade parenchyma. This tissue is not killed as with *Chloridium*, but somewhat hypertrophied, so that the leaf is bent.

Epiphyllic fungi like *Chloridium* and *Ramichloridium* commonly attack the host cells by way of haustoria. Up to now no haustoria have been seen even in well stained microtome sections.

In these sections the palisade parenchyma of the infected leaf chambers was already killed in the living leaf. It seems possible that sections from the marginal parts of speckled spots, where the tissue is not yet killed may show the presence of haustoria in living host cells.

It is impossible to place this ramified *Chloridium* in any existing genus of the Fungi Imperfecti, so it has been named *Ramichloridium musae* nov. gen., nov. spec.

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2. Simmonds, J. H.—Banana Leaf Spot, *Dep. Agr. and Stock, Queensland, Australia, Div. Entom. and Plant Path. Pamphlet* No. 6, pp. 18-19, 1933.
3. Wardlaw, C. W.—Banana Diseases, VIII. Notes on Banana Leaf Diseases in Trinidad, *Trop. Agriculture*, XI, p. 15, 1934.
4. Wardlaw, C. W.—Diseases of the Banana, *MacMillan & Co.*, London, p. 315-316, 1935.

Description of Illustrations.

FIG. 1.—*Conidiophore of Chloridium in glycerine.*

FIG. 2.—*Conidiophore of Chloridium with all the conidia still attached, drawn from a living conidiophore in air.*

FIG. 3.—*Conidiophore of Ramichloridium in glycerine.*

FIG. 4.—*Conidiophore of Ramichloridium, drawn from a living conidiophore in air.*

FIG. 5.—*Typical mycelial covering of the inside surface of a stoma by Ramichloridium.*

FIG. 6.—*A germinated conidium of Chloridium with two appressoria, one of them grown on to a hypha; from a culture in a microculture slide.*

FIG. 7.—*Cross section through a healthy banana leaf (Congo), left a big vein, right two small ones; between the big vein and the first small vein a crosswall.*

FIG. 8.—*Section parallel to the secondary veins showing six crosswalls, one of them with a vascular bundle.*

FIG. 9.—*Infection tube of Chloridium growing through the air chamber and branching on the inside surface of the palisade tissue.*

FIG. 10.—*Stomatopodium of Chloridium in connection with a conidiophore.*

FIG. 11.—*Stomatopodium of Chloridium with epiphyllous mycelium.*

FIG. 12.—*Stomatopodium of Ramichloridium in connection with the epiphyllous mycelium.*

FIG. 13.—*Photo of the lower side of a banana leaf (Congo) with speckled patches and several Cercospora spots, on the right a Cercospora spot enlarged by Cordana.*

FIG. 14.—*Photo of the same leaf as* Fig. 13, *but from the upper-side.*

FIG. 15.—*Part of a speckled spot with diseased (hatched) and healthy leaf chambers.*

FIG. 16.—*Translucent photo of a banana leaf with speckled patches and several Cercospora spots.*

FIG. 17.—*Lower side of a leaf of Pisang Radja with many small velvety spots of Ramichloridium.*

REVIEWS.

THE EARTH GODDESS.

By G. Howard Jones, M.A., *Longmans, Green & Co.*, London, 1936, pp. 205, price 12*s.* 6*d.*

This volume is the twelfth in the series of Royal Empire Society Imperial Studies, and is the result of five years' experience of agricultural practices in Nigeria and Sierra Leone. The author begins his sketch of prevailing conditions by indicating how far West Coast agriculture is acted upon by scientific, economic and social influences. The second chapter, devoted to the agricultural history of the West Coast, is of exceptional interest, and at its conclusion the author gives qualified endorsement to the unfavourable opinions regarding the standard of native agriculture expressed by earlier writers. The social aspects of peasant farming are shown to be dominated by the problems which have resulted from the introduction of civilised methods and ideas, with their inevitably unstabilizing effect on social structure and tribal allegiance.

The author points out that the present system of farming on a small scale by peasants, is not likely to undergo radical alteration, and, after considering at some length systems of farming under métayer and planter, sees in neither a means of raising the general standard of West Coast agriculture, but believes that attention must be concentrated on methods of improving the standard of existing practice, without thought of replacing it.

The second half of the book is occupied with a consideration of methods by which improvement is being attempted: the chief hope of advancement lies in the increased adoption of agricultural co-operation, supplemented by intensified education of the future rural population. Dealing with the curriculum for elementary schools, the author pleads for the inclusion of suitably chosen natural science and health lessons, on the grounds that these subjects, without being vocational, involve scientific principles readily applicable to the child's environment, and afford opportunity for decision and deliberation independent of blind tradition.

A brief index closes the book, and is preceded by a bibliography of just over five pages, in which each title is followed by a useful descriptive annotation.

The book provides a careful presentation of West Coast problems which undoubtedly call for clear thinking at the present time, and is well worth reading. The chapters on fostering progress by means of extension work and education are applicable to all tropical countries where peasant farming forms the principal type of agriculture and especially deserve to receive the attention of those interested in agricultural development.

R. G. F.

* * *

ENGLISH FARMING—PAST AND PRESENT.

Lord Ernle. New Edition by Sir A. D. Hall. *Longmans Green & Co.*, London, 559 pp. 15*s.*

A new edition of this standard work is welcome, for no changes have been made in it since 1912, and there have been great developments in English farming since then. It is doubly welcome from the fact that the revision has been done by Sir A. D. Hall so that it is both complete and authoritative.

The earlier portion of the work remains much as it was, but towards the end will be found new chapters, dealing with agricultural legislation since the war, and education and research. The last chapter is entitled "Technical Progress since the War", and is a fascinating account of modern farming written as only Sir Daniel could write it.

Of the many topics discussed, readers in the tropics will naturally be interested in what Sir Daniel has to say about that modern industry, the raising of sugar beet, which has in 11 years (1924-34), cost Great Britain nearly £48,000,000 in subsidies and remission of excise. The industry has, in his opinion, failed to come up to the expectations with which it was launched, and he does not think it likely that it will find a permanent place in English agriculture. There is little prospect of increasing the yield of sugar from beet, or of reducing the costs of cultivation and manufacture, while the home industry is facing both the heavier protection of beet production in the European countries, and the greatly increased efficiency of cane-sugar cultivation. That the industry has kept many farmers going during the worst of the post-war depression is to its credit, but it is becoming increasingly difficult to find arguments for its continued protection.

Livestock remains supremely important and continues to be the mainstay of English farming, and Sir Daniel has much to say about the industry. He alludes to the mystery of Foot and Mouth disease, which still eludes all attempts to discover how outbreaks reach Great Britain. It was at one time thought the wind or birds might be carriers, but the almost entire freedom from infection during the war, indicated some article of commerce as the most probable carrier. Whatever the cause, the expense of dealing with this disease remains considerable, for nothing has yet emerged to suggest an alternative to the policy of slaughter and isolation.

The rise of the poultry industry since the war has been phenomenal either as a whole-time industry or as an adjunct on a mixed farm, and it will come as a surprise to many to read that it is now of more value than the wheat industry. Unfortunately it has recently suffered a considerable setback from the drop in the price of eggs, partly as a result of the general slump in prices, and partly owing to increasing competition of high-quality eggs imported from Australia and New Zealand. As Sir Daniel puts it: "Despite the introduction of marking regulations 'Fresh eggs, Australian produce' is a label which may be seen in any grocer's shop". Latterly too, disease has begun to assume alarming proportions in many flocks. It is probable that the modern bird, bred too closely for egg production, has not the stamina of the unimproved bird; it is undoubtedly the case that the intensive conditions adopted by modern poultry farmers necessitate a standard of cleanliness and hygienic precautions which the majority of them do not realise. In consequence, mortality has been very heavy and a Government committee of enquiry has recently been set up.

It is of interest to note that the same tendency to specialisation is apparent in England as in the tropics. The tropical peasant is reducing his products from many to a few, while the English farmer is going further and learning to depend on not more than one or two: cases are noted of milk-producers who do not breed their own animals, of egg-producers who buy all their laying birds.

It is hoped that enough has been said to show that this book is one which will appeal to everyone interested in the development of farming and since tropical agriculture is developing rapidly and since it may be surmised that it will follow somewhat similar lines, the book should prove valuable to tropical administrators. R. C. W.

* * *

AN INTRODUCTION TO THE SCIENTIFIC STUDY OF THE SOIL.

By Norman M. Comber, *Edward Arnold & Co.*, London, 1936. Third Edition. pp. 206. Price 7*s*. 6*d*.

In the opinion of the reviewer, this is the best class book on the fundamentals of soil science that has yet been published in the English language. It forms an excellent introduction to the subject for students who have already received elementary training in chemistry, physics, geology and botany. For these reasons, Professor Comber's book has been selected as text book for Diploma Students at the Imperial College of Tropical Agriculture. The first edition was issued in 1927 and reprinted in 1929; the second edition appeared in 1932, and already a third edition has been found necessary. This latest edition (December 1936) is thoroughly up-to-date; it contains a new chapter on the minerology of clay, and other chapters dealing with humus, mineral soil colloids, clay flocculation, the water relations of soil, and field experimentation, have been revised and partly rewritten. The sole object of the book is at present "a general conception of soil constitution and phenomena". The treatment is broad yet concise. Most aspects of soil science are considered, such as soil genetics, mineral nutrients and nitrogen, soil classification, and the water, air and temperature relations of soil. Special consideration is given to the chemistry of the soil, involving a discussion of the important base exchange phenomena and soil acidity, which are particularly clearly presented. A chapter on the literature of soil science forms a useful addition to the book. The text throughout is illustrated by tables and diagrams, none of which is superfluous; the printing and arrangement are attractive, and the price is reasonably low.

* * * F. H.

THE QUANTUM THEORY OF VALENCY.

By W. G. Penney, A.R.C.S, M.A., Ph.D., *Methuen & Co.*, London, 1936, 96 pages, price 2*s*. 6*d*.

The study of the molecular structure of chemical compounds has made rapid strides in recent years. The originally simple concept of valency has been developed, and nowadays bond-diagrams are being used to express the energy relationships underlying the architecture of molecules. In this book, the application of quantum mechanics to problems concerning molecular structure is described, and the use of mathematics in the interpretation of certain fundamental chemical reactions is illustrated. To students needing a concise review of this aspect of chemistry, Dr. Penney's book can be strongly recommended.

F. H.

THE LATE DR. BRITON-JONES.

Sir James Currie, K.C.M.G., K.B.E., who was Chairman at the 143rd meeting of the Governing Body of the College which was held at the Colonial Office on 9th December, moved the following resolution which was carried unanimously, all the Governors present standing in their places. "That the Governing Body have learnt with deep regret of the death on 3rd November of Dr. H. R. Briton-Jones, D.Sc., Ph.D., D.I.C., A.R.C.S., Professor of Mycology and Bacteriology of the Imperial College of Tropical Agriculture since 1926 and Dean since 1927, and desire to place on record their appreciation of his services and to convey to the relatives the expression of their sympathy".

THE CACAO INDUSTRY OF TRINIDAD.—*Continued.*

SOME ECONOMIC ASPECTS.

Series II.—A financial survey of estates during the seven years 1923-4 to 1929-30.

By C. Y. Shephard.

PART V.—COMPARISON OF VARIOUS GROUPS OF ESTATES.

The preceding analyses suggested that, apart from prices, yields of cacao per acre are primarily responsible for the magnitude of the profits or losses of various groups of estates. Estates which are exceptionally large or small appear less profitable than those of average size. Yields appear to bear no relation to the amounts expended on cultivation. The youngest cacao growing districts are the most profitable, and the oldest district is the least profitable, but one group of old estates is even more profitable than the youngest districts. In the following four sections the estates are grouped according to (*a*) yields, (*b*) size, (*c*) expenditure, and (*d*) age, in order to reveal more directly the relation between these factors and profits.

SECTION (*a*).—COMPARISON OF ESTATES GROUPED ACCORDING TO YIELD. (*See* TABLE VI AND FIGS. XX-XXV.)

Profits and Costs of Production (*See* Figs. XXIV, XXV and XXI).

An examination of estates arranged in yield classes shows that those producing less than three bags of cacao per 1,000 pickets incurred a loss of $1.09 (4*s*. 6½*d*.) per acre. Each of the remaining five classes secured profits, rising steadily with yield from $2.80 (11*s*. 8*d*.) on those giving four bags per 1,000 pickets, to $24.90 (£5 3*s*. 9*d*.) on those giving 11 or more bags per 1,000 pickets. Thus, there appears to be a close relationship between yields and profits. Costs of production per bag of cacao are related inversely to yield. The least productive estates produced at the very high cost of $21.89 (£4 11*s*. 2½*d*.) per bag, contrasted with $10.02 (£2 1*s*. 9*d*.) on the most productive estates. The lowest cost of production, $9.82 (£2 0*s*. 11*d*.), was shown by the second most productive class.

Expenditure on Cultivation (*See* Fig. XXII).

There is a tendency for each increment in yield to be accompanied by an increase in the total expenditure per acre. Thus, the class with the lowest yields spends only $17.44 (£3 12*s*. 8*d*.) per acre, whereas that with the highest yields spends as much as $30.28 (£6 6*s*. 2*d*.) per acre. This wide disparity in expenditure, however, provides no explanation of the difference in yield. It is, in fact, surprising to find that the most productive estates spend only $6.67 (£1 7*s*. 9½*d*.) per acre on cultivation, whereas the least productive estates spend $9.12 (£1 18*s*. 0*d*.). In the remaining four classes yields range from four to ten bags of cacao per 1,000 pickets, but expenditure on cultivation differs by only 71 cents (2*s*. 11½*d*.) per acre. There is considerable variation in the expenditure on individual items of cultivation from class to class, but none of these differences has any obvious significance. The expenditure on cultivation by the class producing four bags per 1,000 pickets is much the same item for item as that of the class yielding ten bags, except that the latter spends more on draining. Yet the highest yielding class of all is conspicuous for its low expenditure on draining. It is of interest to note that the lowest yielding class spends 58 cents (2*s*. 5*d*.) per acre on the purchase of manures, and the next class only two cents (1*d*.). None of the better yielding classes purchases any manure.

Total Expenditure (*See* Figs. XX and XXI).

The increase in total expenditure per acre with yield is due entirely to items other than cultivation. Heavier crops necessitate greater expenditure on reaping, manufacture, stock, buildings, bags, transport, &c. For example, the least productive estates spend only $1.29 (5*s*. 4½*d*.) per acre on reaping, whereas the most productive estates spend $4.21 (17*s*. 6½*d*.). The cost per bag of reaping, however, is $1.57 (6*s*. 6½*d*.) on the lowest yielding group, compared with $1.39 (5*s*. 9½*d*.) on the highest yielding group. Another factor tending to increase the total expenditure on high yielding estates is their ability to spend more in keeping buildings, roads, bridges, &c., in good condition. Low yielding estates find it necessary to stint expenditure on all items except those of urgent necessity. With the exception of the second most productive group, there is an appreciable rise in the expenditure on management and supervision with each increment in yield. Thus, the highest yielding estates spend an average of $6.81 (£1 8*s*. 4½*d*.) per acre on this item, whilst the lowest yielding estates spend

only $3.04 (12s. 8*d.*). The greater part of this difference is accounted for by the payment of larger salaries to the managers of the more productive estates. The greater profitableness of the high yielding estates enables them, in general, to attract the more skilled managers and they, in turn, further tend to enhance the profitableness of these estates. It would be, however, a gross exaggeration to say that the large profits of certain estates are due primarily to the employment of the most efficient managers, or that the losses of other estates are attributable to inefficient managers.

Subsidiary Crops (Items 23, 32 and 33, Table VI).

The fall in revenue from crops intercultivated with cacao from 85 cents (3*s.* 6½*d.*) per acre on the lowest yielding estates, to eight cents (4*d.*) on the highest yielding estates, supports the conclusion that interplanting has proceeded most extensively on the poorest cacao areas. The highest cacao yielding class spends most on subsidiary crops planted separately from cacao, but is followed by the lowest cacao yielding class. The former obtains 24 per cent. of its total income, and the latter 21 per cent. from sources other than cacao. It will be noted that the most successful cacao estates derive a large profit from subsidiary crops while the least successful incur a small loss. There is no doubt that conditions on the best cacao estates are well suited to a number of other crops, but the inference that the poorest cacao estates are equally unsuited to alternative crops must be qualified by the fact that appreciable areas of the new crops are not yet in full bearing and by the possibility that the most suitable crops have not been tried. Every other group of estates shows a profit on subsidiary crops, but the revenue from this source does not exceed 12 per cent. of the total in any group, and is less than one per cent. in the group yielding ten bags of cacao per 1,000 pickets.

Mortgages (Item 39, Table VI).

There is a rapid rise from the lowest to the highest yielding classes in the amounts paid in interest on mortgages. The least efficient cacao estates pay the equivalent of only 31 cents (1*s.* 3½*d.*) in interest for each acre under cacao, whereas the most efficient group pays $5.19 (£1 1*s.* 7½*d.*). The latter charge was borne with ease during 1923-4 to 1929-30, but since then has constituted a heavy burden owing to the severe fall in cacao prices. The incidence of mortgages again suggests that the more efficient estates were enabled to raise more capital by mortgages, but the fact is that most of the least efficient estates were acquired by the mortgagees, because of the failure to maintain payments of interest, and now appear unencumbered.

Yields (*See* Fig. XXIII).

It is astonishing that the most productive estates are able to earn such large profits with an average annual yield of less than 24 pods of cacao per picket. Individual trees selected by the Cacao Research officers yield at a rate exceeding one ton of cacao per acre, or more than four times that of the present highest yielding class. Although it is impossible to raise the yield of every estate to this high level there appears ample scope for improvement. Some fields at one time gave more than half a ton of cacao per acre, but have since declined seriously in productivity. The discovery of the causes of falling yields may indicate means whereby production can be raised beyond its previous maximum with the new aid of selected planting material. There appears little hope, however, of improving the least efficient estates to a profitable level with existing low prices. Their annual yields are less than six pods per picket.

Size of Estates (Item 42 Table VI).

The fact that the least productive estates are about twice the average in size supports the suggestion made in Part IV that estates of abnormal size are less profitable than the average. In the next section the estates are examined in size groups.

Summary.

There is a close relationship between the yields and profits of various groups of Trinidad cacao estates. Costs of production per bag of cacao are related inversely to yield. Each increment in yield is accompanied by an addition to the total expenditure per acre, but there is little difference between the yield classes in expenditure on cultivation except that the lowest yielding class spends much above the average. Heavier yields necessitate greater expenditure on reaping, manufacture and equipment, while larger profits permit the better maintenance of buildings and the payment of better salaries. There is an almost uninterrupted decline in revenue from intercultivated crops from the lowest to the highest yielding classes. The expenditure on separate areas of subsidiary crops, however, is greatest on the most productive cacao estates, and next highest on the least productive estates. Conditions on the most efficient cacao estates are well suited to a variety of other crops, but on the least efficient cacao estates there is difficulty in finding profitable alternative crops. Interest charges on mortgages rise from class to class with yield, primarily because of the foreclosure of mortgages on the less profitable estates. Even the highest yields offer scope for great improvement, but it is unlikely that the lowest yielding estates will ever become profitable. The least efficient estates are nearly twice the average in size.

COMPARISON OF TRINIDAD CACAO ESTATES GROUPED ACCORDING TO YIELDS IN BAGS PER 1,000 PICKETS, 1923-4 TO 1929-30

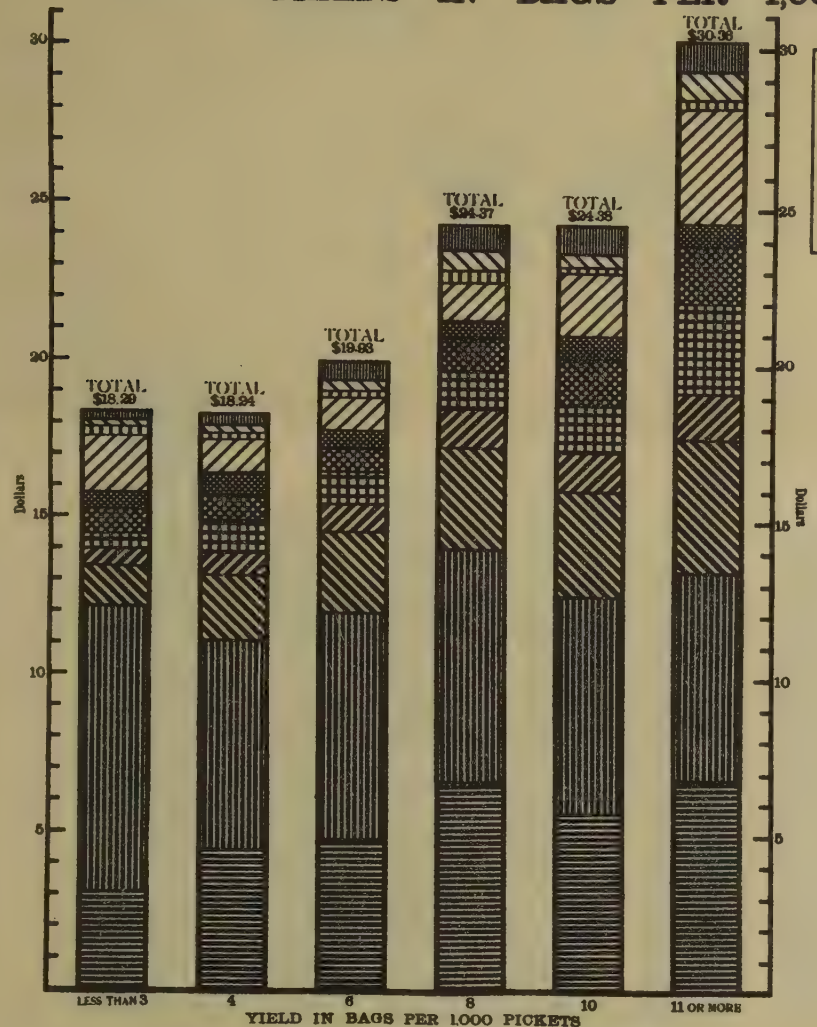
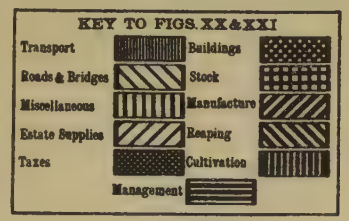


FIG. XX. AVERAGE ANNUAL EXPENDITURE PER ACRE



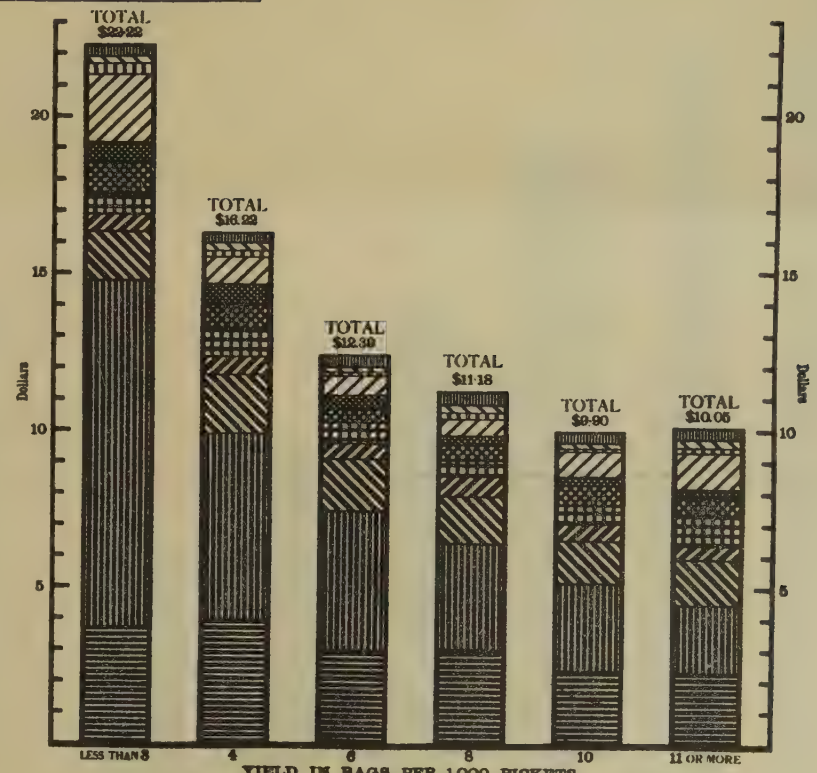


FIG. XXI. COST OF PRODUCTION PER BAG (165 lb.) OF CACAO

COMPARISON OF TRINIDAD CACAO ESTATES GROUPED ACCORDING TO YIELDS IN BAGS PER 1,000 PICKETS, 1923-4 TO 1929-30

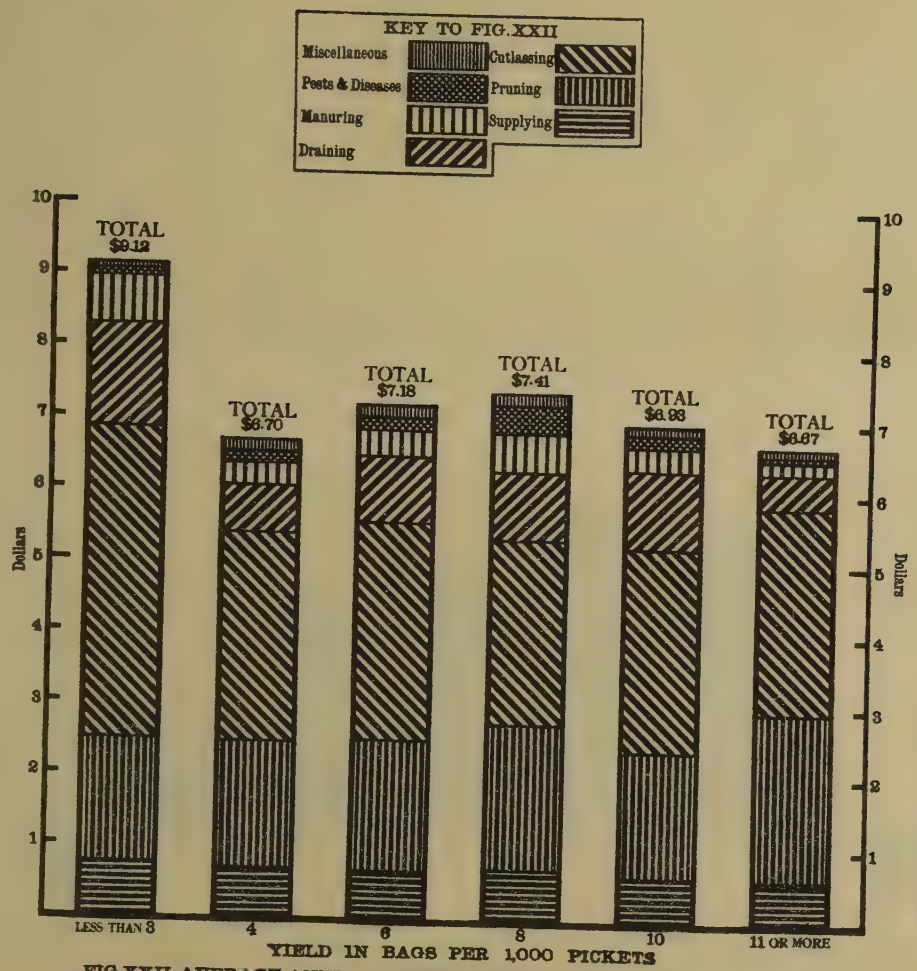


FIG. XXII. AVERAGE ANNUAL EXPENDITURE PER ACRE ON CULTIVATION

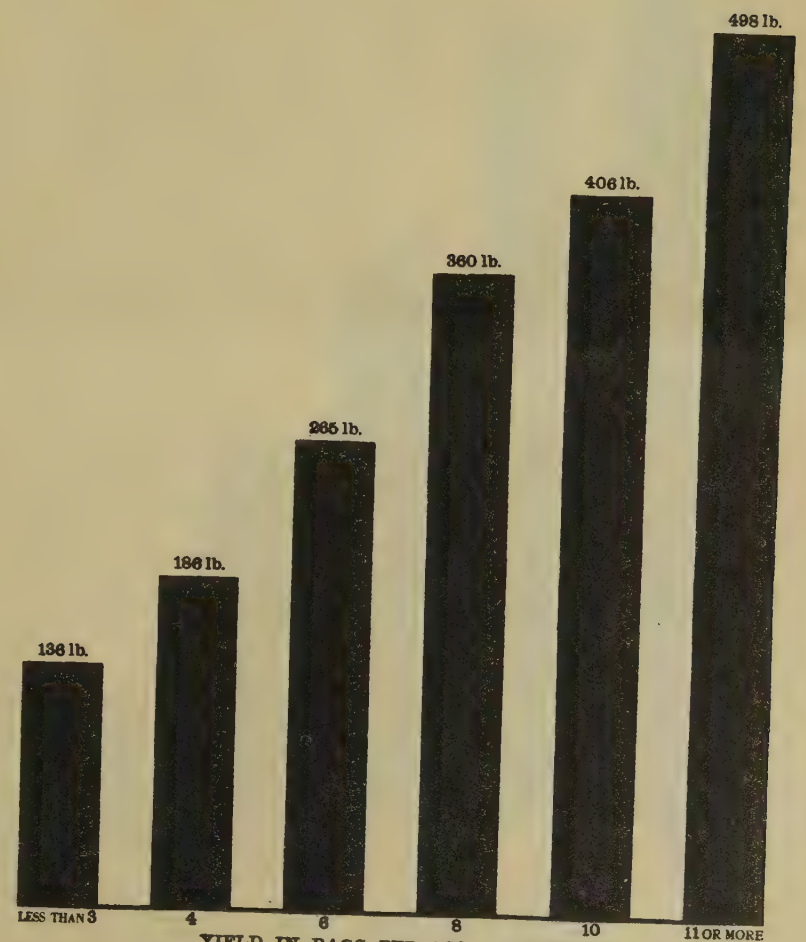


FIG. XXIII. AVERAGE ANNUAL YIELD PER ACRE

COMPARISON OF TRINIDAD CACAO ESTATES GROUPED ACCORDING TO YIELDS IN BAGS PER 1,000 PICKETS, 1923-4 TO 1929-30

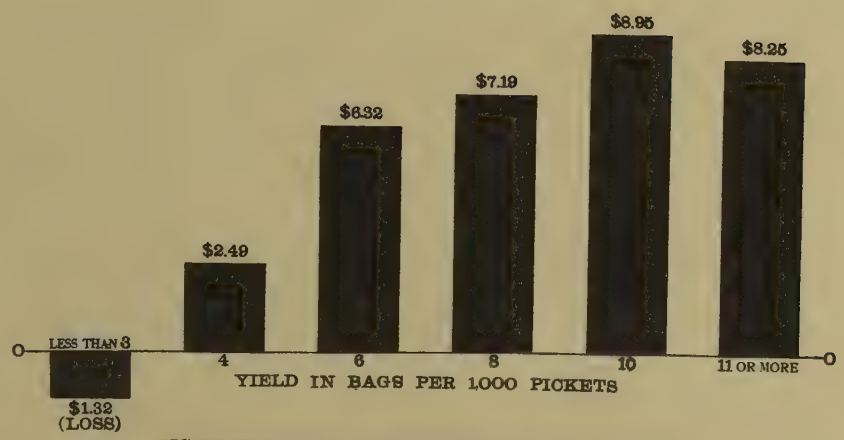


FIG XXIV. PROFIT OR LOSS PER BAG (165 lb.) OF CACAO

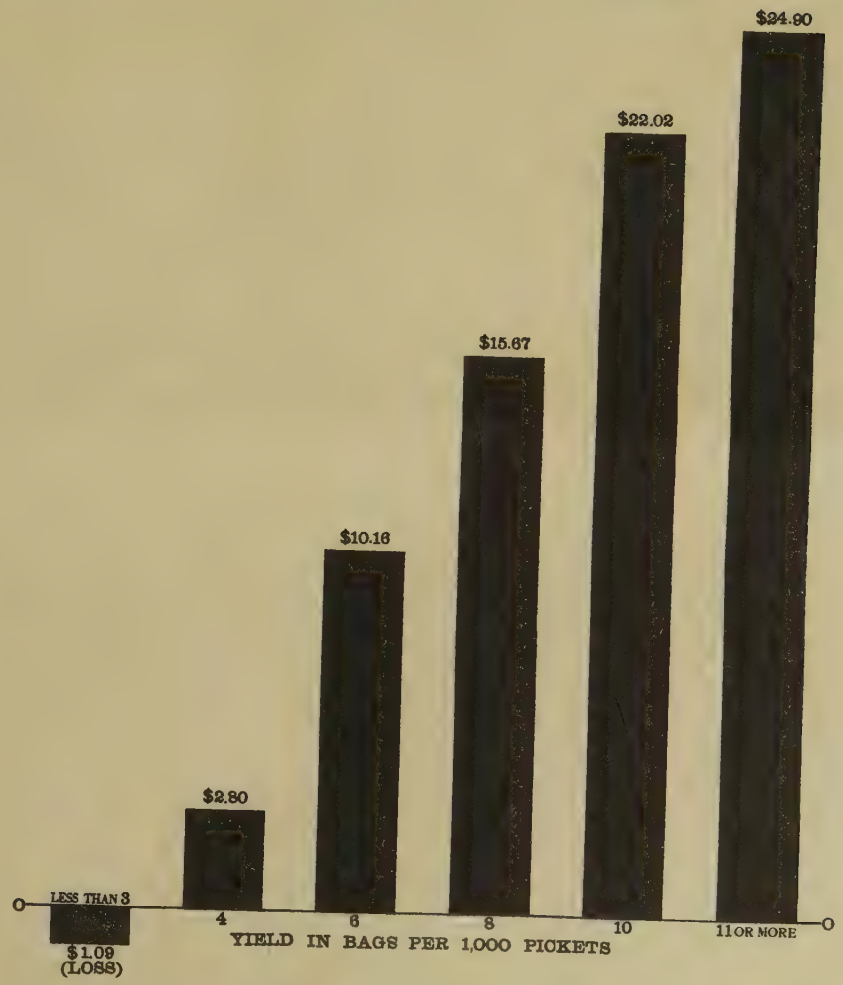


FIG XXV. AVERAGE ANNUAL PROFIT OR LOSS PER ACRE

Table VI.—Analysis of the Expenditure, Revenue, &c., of 126 Trinidad Cacao Estates grouped according to **YIELD IN BAGS (165 lb.) OF CACAO PER 1,000 PICKETS** for the Seven financial years 1923-4 to 1929-30.

No.	Item. Description.	Expenditure Per Acre of Cacao. Yield in Bags per 1,000 Pickets. Under 3	4	6	8	10	11 or more.	Cost Per Bag (165 lb.) of Cacao. Yield in Bags per 1,000 Pickets. Under 3	4	6	8	10	11 or more.	Item No.
		$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	
1	Management and Supervision	3.04	4.40	4.75	6.58	5.68	6.81	3.70	3.91	2.96	3.02	2.31	2.25	1
	Cultivation:													
2	"Supplying" Cacao Trees	.76	.69	.66	.70	.62	.59	.92	.62	.41	.32	.25	.20	2
3	Trimming and Pruning Trees	1.73	1.77	1.84	2.05	1.76	2.36	2.09	1.57	1.14	.94	.72	.78	3
4	Cutlassing and Weeding ..	4.37	2.93	3.03	2.61	2.86	2.89	5.31	2.60	1.88	1.20	1.16	.95	4
5	Draining and Roundridging	1.44	.67	.98	.95	1.11	.48	1.75	.60	.61	.44	.45	.16	5
6	Applying Manure ..	.64	.29	.33	.53	.33	.18	.78	.26	.21	.24	.13	.06	6
7	Pests and Diseases ..	.10	.18	.20	.40	.15	.05	.12	.16	.13	.18	.06	.02	7
8	Miscellaneous Cultivation	.08	.17	.14	.17	.10	.12	.10	.15	.08	.08	.04	.04	8
9	Total Cultivation ..	9.12	6.70	7.18	7.41	6.93	6.67	11.07	5.96	4.46	3.40	2.81	2.21	9
10	Reaping	1.29	2.10	2.62	3.26	3.34	4.21	1.57	1.87	1.63	1.49	1.36	1.39	10
11	Manufacture	.46	.64	.87	1.23	1.23	1.49	.56	.57	.54	.57	.50	.49	11
12	Live Stock	.52	1.01	1.02	1.22	1.50	2.87	.63	.90	.64	.56	.61	.95	12
13	Buildings	.80	.84	.73	1.07	1.54	1.84	.98	.74	.45	.49	.62	.61	13
14	Taxes	.51	.71	.61	.52	.69	.66	.61	.63	.38	.24	.28	.22	14
	Estate Supplies:													
15	Manures	.58	.02	..	..	..	..	.70	.02	..	..	..	..	15
16	Feed	.37	.37	.37	.39	.67	1.58	.45	.33	.23	.18	.27	.52	16
17	Other	.82	.61	.68	.80	1.30	2.08	1.00	.54	.42	.36	.53	.69	17
18	Total Supplies ..	1.77	1.00	1.05	1.19	1.97	3.66	2.15	.89	.65	.54	.80	1.21	18
19	Miscellaneous	.29	.21	.16	.45	.21	.29	.35	.19	.10	.21	.09	.10	19
20	Roads and Bridges ..	.22	.26	.32	.61	.44	.89	.27	.23	.20	.28	.18	.30	20
22	Total Cost	18.02	17.87	19.31	23.54	23.53	29.39	21.89	15.89	12.01	10.80	9.56	9.73	22
23	Revenue from Inter-cultivated crops ..	.85	.57	.44	.12	.20	.08	1.03	.51	.27	.05	.08	.03	23
24	Cost of Estate	17.17	17.30	18.87	23.42	23.33	29.31	20.86	15.38	11.74	10.75	9.48	9.70	24
25	Transport to Merchant's Store	.27	.37	.62	.83	.85	.97	.33	.33	.38	.38	.34	.32	25
26	Cost at Merchant's Store ..	17.44	17.67	19.49	24.25	24.18	30.28	21.19	15.71	12.12	11.13	9.82	10.02	26
29	Revenue from Cacao ..	16.35	20.47	29.65	39.92	46.20	55.18	19.87	18.20	18.44	18.32	18.77	18.27	29
30	Profit on Cacao ..	..	2.80	10.16	15.67	22.02	24.90	..	2.49	6.32	7.19	8.95	8.25	30
31	Loss on Cacao	1.09	..	..	..	..	..	1.32	..	..	..	..	..	31
32	Other Expenditure ..	5.62	1.73	1.28	2.62	.41	8.51	6.82	1.54	.79	1.20	.17	2.82	32
33	Other Revenue	4.34	2.87	1.66	3.63	.87	17.80	5.27	2.55	1.03	1.67	.35	5.89	33
34	Total Expenditure ..	23.06	19.40	20.77	26.87	24.59	38.79	28.01	17.25	12.91	12.33	9.99	12.84	34
35	Total Revenue	20.69	23.34	31.31	43.55	47.07	72.98	25.14	20.75	19.47	19.99	19.12	24.16	35
36	Profit	..	3.94	10.54	16.68	22.48	34.19	..	3.50	6.56	7.66	9.13	11.32	36
37	Loss	2.37	..	..	..	..	..	2.87	..	..	..	..	..	37
38	Interest Received	.01	.04	.02	.01	..	.04	.01	.04	.01	..	..	.01	38
39	Interest Paid	.31	.78	2.39	2.58	5.44	5.19	.38	.70	1.49	1.18	2.21	1.72	39
40	Net Profit	..	3.20	8.17	14.11	17.04	29.04	..	2.84	5.08	6.48	6.92	9.61	40
41	Net Loss	2.67	..	..	..	..	..	3.24	..	..	..	..	..	41
		Total.						Average.						
42	Cacao Acreage	3,613	10,468	8,683	5,692	2,881	883	516	233	255	219	262	294	42
43	No. of Cacao Pickets in 1000's	1,045	2,874	2,465	1,579	743	238	149	64	72	61	67	79	43
44	Valuation in 1000's $ ..	363	2,275	1,877	1,988	833	331	52	50	55	76	76	110	44
45	Yield in bags of Cacao ..	2,974	11,775	13,958	12,402	7,094	2,666	425	262	411	477	645	889	45
46	Yield in bags per 1000 pickets	..	..	..	..	..	..	2.85	4.10	5.66	7.85	9.54	11.21	46
47	Yield in lb. per acre ..	..	..	..	..	..	..	136	186	265	359	406	498	47
48	Yield in lb. per picket ..	..	..	..	..	..	..	.47	.68	.93	1.30	1.57	1.85	48
49	Price of Cacao per fanega in $	..	..	..	..	..	..	13.24	12.13	12.29	12.21	12.51	12.18	49
50	Per cent. return on capital ..	..	..	..	..	..	..	2.35 (loss)	1.81	4.87	4.78	7.77	9.12	50
51	No. of estates surveyed ...	7	45	34	26	11	3	..	..	..	..	..	..	51

METHOD OF KILLING STANDING TREES.

By C. Swabey,
(*Assistant Conservator of Forests, Trinidad.*)

Introduction.

It is often necessary in agricultural and forest practice to remove unwanted standing trees, particularly trees utilised for shade purposes as in the case of immortelle shading cocoa.

The obvious method, *i.e., felling* the trees, has certain serious disadvantages and several ways of avoiding this have been in use for many years. Amongst the most serious disadvantages of felling is the damage caused to valuable trees or crops growing below the tree to be felled: a large-crowned tree with heavy foliage may, if felled, cause grave damage to the very crops in the interest of which the felling is to be carried out. In addition, the felling of large trees is relatively expensive and may be followed by coppice growth from the cut stumps which will in turn have to be cut back from time to time.

To counteract these disadvantages the following methods have been tried out in various parts of the world:—

(*a*) *Girdling.*—This is done either by removing a ring of bark round the tree or by cutting into the wood of the tree by a series of axe cuts.

(*b*) *Poisoning.*—A poison, usually an arsenical solution, is either applied to the tree after girdling or is poured into holes bored into the base of the tree with an auger.

Girdling.

The basic object of girdling is so to interrupt the sap circulatory system of the tree that death will eventually follow. It is necessary to remember that the upward channel of conduction is *via* the tracheae in the outer layers of the wood, and that the subsequent distribution of the elaborated food material is *via* the sieve tubes of the bast tissue. The removal of the bast, as in ring-barking, merely prevents the access of food materials to the root system and the tree will not begin to die until all available soil nutrients have been absorbed by the existing root system and, apparently, until all available food reserves in the tree have been exhausted. Of greater importance in killing the tree is interruption of the *upward* flow by cutting into the wood itself: the extent to which sap flow is limited to the outer layers of the wood varies enormously with different species. In trees in which heartwood is formed at an early stage, involving the blocking of vessels by tylosis development, a very shallow cut into the sapwood may interfere with the flow so seriously as to kill the tree. In other species, the wood may maintain its ability of conduction almost to the centre of the tree: a shallow girdle on such a tree might be virtually ineffective in killing it (1).

In Trinidad, callus formation of a number of species is extremely rapid after girdling and the normal closed sap circulation system may thus be re-established before the tree has succumbed to the interruption: food supplies may be further increased by the formation of epicormic foliage both above and below the girdle.

The principal advantages of girdling, as opposed to felling, may be summarized as follows:—

(*a*) The damage done is substantially minimised: first the leaves fall, then the twigs and small branches and finally the actual trunk of the tree.

(*b*) The tree dies slowly and the lightening effect is spread over a considerable period, thus avoiding violent alteration of the micro-climatic factors.

(*c*) The method is cheaper than felling.

The major disadvantage is the relative uncertainty of the method: if shallow girdling is practised, callus may be formed and the tree may recover. If the girdling is deep the tree may be so weakened that it falls with a gust of wind before the leaves or branches have dropped. For these reasons the use of poisons, either by themselves or to supplement girdling, has shown considerable development.

Poisoning.

Experiments in India in 1918 (2) proved the value of the application of poison after girdling in increasing the proportion of trees killed and the rapidity with which they died. Subsequent work in Malaya (3) and in Trinidad (4) confirmed these results, but the high cost of the proprietary compound employed rendered the economic application of the method impracticable. Interest in the subject was however stimulated in 1932 by the work of MacKinney and Korstian (5) in the U.S.A. Working with commercial arsenious oxide and elaborating a method which they named "frill-girdling", they achieved highly successful results at a comparatively low cost. Adaptation of this technique in Malaya has revolutionised improvement and regeneration methods in the forests and is of the greatest importance in the silvicultural policy of the local Forest Department (6).

Briefly, the method is as follows: the frill consists of a ring of downwardly directed axe cuts which run into each other forming a groove or trough round the tree into which the poison is poured from an oil can. The poisoning should take place as soon as possible after the frill girdle has been cut, so that it may be transported in the transpiration stream: if the girdle is allowed to dry, the poison can only find its way by the infinitely slower process of diffusion (7).

The older method of ring-barking (*i.e.*, not cutting into the wood) and subsequent painting of the barked portion with the poison has not proved nearly as certain and may be completely invalidated by rain falling soon after poisoning.

The following experiment carried out recently by the Forest Department in Trinidad, though admittedly on a small scale, offers a valuable indication of the efficiency of "frill-girdling".

Eighty trees in the Arena Forest Reserve were selected, 20 were girdled and not poisoned, 20 were ring barked and Atlas preservative applied full strength, 20 were ring barked and sodium arsenite solution (1 lb. to 1 gallon) applied, and 20 were "frill-girdled" and sodium arsenite (of the same strength) applied.

Treatment.	Date of treatment.	Number killed in days							
		15	30	45	60	90	120	150	180
Trees girdled and not poisoned	13.4.36	0	0	1	1	1	4	5	7
"Atlas" applied after ring-barking	4.5.36	5	12	12	12	18	18	20	—
Sodium arsenite applied after ring-barking	4.5.36	7	13	13	13	19	20	—	—
Sodium arsenite applied after frill-girdling	13.7.36	6	9	16	20	—	—	—	—

It will be noted that at the end of six months only seven out of the 20 girdled trees had died, whereas *all* the frill-girdled and poisoned trees were dead within two months. A further advantage of this method over plain girdling is that the stumps are killed and do not coppice.

In Malaya, after very extensive trials, the following conclusion was reached: "Ordinary girdling (to a depth varying from ½″ to 2″ with the size of the tree) gives a mortality of 75 per cent. in 18 months and two-thirds of the balance in three years. Much more expeditious and certain results may be obtained by frill-girdling with the use of sodium arsenite solution as a poison, the mortality reaching 83 per cent. in six months" (6). On the other hand in the mixed hardwood stands of the Southern States of the U.S.A. it is reported that "poisoning is usually unnecessarily expensive and unjustified by any outstanding or consistent advantages" (8). This view is not supported by experience in the tropics.

Sodium arsenite appears to be the most satisfactory poison, and it is infinitely cheaper than the majority of proprietary arsenical preparations. The landed cost of sodium arsenite in Trinidad is $8.04 (£1 13*s.* 4*d.*) per cwt., of which $1.36 (5*s.* 8*d.*) represents freight and premium. This works out at 7.2 cents (approx. 3½*d.*) per lb.

The normal strength of solution is 1 lb. of sodium arsenite to one gallon of water, but current work in Malaya has indicated that this concentration may be reduced (7). Under experimental conditions in Trinidad it was found that two men could deal with 60 trees (average girth 2′ 6″) per day, provided the trees are close together, and that 40 trees could be treated with one gallon of solution. The average cost of treatment per tree was, therefore, approximately two cents, a figure far below the cost of felling and lopping.

The boring of holes in the base of the tree with augers is commonly practised in Trinidad, but this is only effective in the case of highly susceptible trees. In most species the transfusion of the poison is mainly in a vertical direction and often results in the partial killing of the tree, *i.e.*, one branch only may die. This is borne out by the fact that partial girdling and poisoning is not efficacious: there is but little horizontal percolation of the poison and the tree may maintain life for an extended period if even a small portion of the cambium is left intact and unpoisoned.

It has been claimed that poisoning renders the timber toxic and immune to insect attack and apparently a certain measure of success has been obtained using a solution of mercury bichloride on certain trees in the U.S.A. Results in Trinidad using sodium arsenite and "Nokula*" have indicated that neither of these preparations prevent insect attack (9).

Summary.

(i) The felling of unwanted trees in forest or agricultural operations often causes excessive damage and has other disadvantages.

(ii) Girdling minimises the damage considerably but is by no means certain in its effect.

(iii) The method of "frill-girdling" followed by an application of sodium arsenite solution is the most satisfactory method of killing standing trees, as it is both cheap and effective.

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(6) Strugnell, E. J.—"The girdling of forest trees." *Malayan Forester*, Vol. III, p. 170, 1934.
(7) Research Items. *Malayan Forester*, Vol. IV, p. 52, 1935.
(8) Bull, H. and Chapman, R. A.—"Killing undesirable hardwoods in southern forests." *Southern Forest Expt. Sta. Occ. Paper* No. 50, New Orleans, U.S.A. 1935. (includes bibliography of American references).
(9) Swabey, C.—"Notes on insect attack on Mora." *Forest Dept. Leaflet* No. 6, p. 34, Trinidad, 1933.

* This is a preparation, the makers of which claim that, if applied to a girdled tree, it will render the timber immune to insect attack, and will hasten seasoning.

ERRATUM.

REVIEW.—The Study of the Soil in the Field. Vol. XIII, No. 12, page 333, line 2. Price: *for* 2*s.* 6*d.* *read* 5/-.

HUMUS.

[EDITOR'S NOTE.—*The following brief article forms the subject matter of the Monthly Letter for August, 1936, issued by the Imperial Bureau of Soil Science, Rothamsted Experimental Station, England. It is based on impressions obtained on reading Dr. S. A. Waksman's new book called* "HUMUS", *recently reviewed under* "BOOK REVIEWS" *in* "*Tropical Agriculture*" (Vol. XIII, No. 9, p. 249).]

The soil-characteristic which distinguishes pedology from all other sciences is the existence of humus. Pedology will sooner or later be recognized as humus ecology, to which all other cognate sciences will contribute their mites. The reasons why recognition of this fact has been delayed are firstly, that the cultivator can make big temporary profits while destroying his soil, and secondly, that humus problems make most other problems in soil science look like child's play. If a research worker seeks early disillusionment, or wishes to propound an untenable theory, let him study humus. Most pedological text-books hedge the humus question, since their object is to show how much rather than how little we know, and until recently only one (Glinka's 'Pedology') had admitted the overwhelming importance of humus in soil science by allotting Chapter I to its treatment. Professor S. A. Waksman has now published a monograph on humus which, since it exposes all our knowledge and ignorance of the subject, can justly claim to be one of the most complete introductions to pedology yet written. Even if it leaves one guessing at the end, it should be available to all soil research workers who sooner or later will be brought up against the unsolved puzzles presented by humus.

Fewer or no new and unpublished results are mentioned in the book, but the published works referred to number over 1,300, and may be said to include all which have furthered our knowledge of humus in any way. Digestion of this mass of ink and paper must itself have been a colossal task, and it is to be hoped that the well-digested product will serve both as a warning and a guide to those heroic scientists who must tread the only path which will lead to a deeper understanding of the soil. Facts innumerable have been ascertained about humus but few of them concern the soil; those that do will usually be found on close examination to be hypotheses. Waksman himself repeats the well-worn summary of our knowledge of what humus does; it improves the soil physically and modifies its biological nature, producing conditions favourable to plant growth. So will many other things and treatments, but nothing can replace humus, and all our chemistry, physics and microbiology cannot tell us why. Microbiological science has given us a deeper insight into the process of humus *formation*, which, strictly speaking, is not a soil process, and has much in common with other putrefactions, but cannot explain humus decomposition, and why the highly resistant humic residue of compost heaps and forest litter disappears so completely when it becomes an integral part of the soil. This is a profoundly significant fact, and such explanations as have been offered are largely hypothetical. Were humus decomposition merely a continuation of the humus-forming process, we should expect to find in soil, as we find in compost heaps, a steady accumulation of lignin-like products, whereas actually in a fertile uncultivated soil the humus appears to remain remarkably constant, both as to quantity and quality, over long periods of time. No micro-organisms have yet been found which will effect the complete oxidation of humus, which is probably the fundamental cause of natural sustained fertility, chemical, physical and biological. Bolstering-up chemical fertility by artificial fertilizers has limitations and grave consequences, which are being more and more realized, and over wide areas even the plough and harrow are regarded as dangerous implements. The ultimate wisdom of most measures of land "improvement" must remain in doubt until we understand not only what humus does, but how it does it. The unique position of humus as the link between the living and inanimate worlds demands that that special pedological technique, of which so much is heard and so little known, should be developed and used in solving its mysteries. The now apparent dangers of indiscriminate land exploitation may provide a greater incentive than has yet existed to the development of a new soil science centering round humus. The foundations on which that science might be built are described in Professor Waksman's book, but at present they are only foundations.

One gets the impression in reading the book that "humology", as it has been called, is still largely a test-tube science, awaiting the release that will come when a technique has been devised analogous to that which merged biochemistry into biology. Waksman devotes a chapter to "Soil Humus and the Science of Pedology", which shows clearly that humus and pedology are still parallel rather than identical studies. That humus in all its forms is the chief agent in differentiating the principal profile types is widely recognised, but as Waksman says "the available evidence at the present time is limited largely to a knowledge of the total humus content of the soil". Our knowledge of the composition and formation of peat and manure humus is relatively advanced (largely owing to Waksman's own work), but when we come to *soil* humus, which is as different from peat and manure as the products of digestion are from fresh food, we are on still practically virgin ground. It

cannot be too clearly recognized that the study of soil humus is little more advanced now than it was in Virgil's time, chiefly because pedologists have been so diffident in striking new trails away from the well-worn paths of the older sciences. Hence we regard Professor Waksman's latest book as an admirable and indeed indispensable introduction to a pedology which does not yet exist. Humus has opened up new fields of research to the chemist, physicist and microbiologist, but it must be admitted that the latter have hitherto thrown little light on the real "how-and-why" of humus. When soil science has learnt to utilize other sciences to the same advantage as these have used the soil, it will be worthy of a more pleasing and less ambiguous name than pedology.

SUGAR NOTE.

Compiled by the College Department of Sugar Technology.

Maturity Testing of Cane.

One session of the agricultural section of the International Society of Sugar Cane Technologists, Queensland Congress 1935, was devoted to a symposium on the methods used for the determination of maturity of cane. The advantages to the mill of a supply of cane in condition to give high recoveries is so great that, as is pointed out in one of the papers, it is a matter of surprise that greater attention has not been devoted to the field determination of maturity, the complexity of the problem being offered as the probable explanation. There is, however, a further need for a reliable method, namely, for the determination of the potential value of new seedling canes. Both aspects are referred to in the course of the papers read.

The session was opened with an account of the methods adopted in Barbados, given by G. P. Stevenson, in the case of seedlings, in the selection of which they form an important stage. The tests are made at the stage when the seedling varieties are growing in plots of 16 stools at one or both of the testing stations representing the low and high rainfall regions of the island. Each plot is reaped in three stages, early, medium and late, and sample bundles weighing 100 lb. are crushed for the determination of sucrose in the juice. In plantation fields no testing is carried out though preliminary tests with the hand refractometer have been started.

H. H. Dodds briefly described the method in use in South Africa. At the experiment station the canes are sampled once a month from the commencement of the ripening season and tested for sucrose, purity, juice and more particularly reducing-sugar ratio. A rough indication of the general course of ripening is thereby obtained. On estates a somewhat similar method is adopted but limited to an analysis of juice only with the sucrose content of the cane calculated by an assumed Java ratio. Claims have been advanced by some planters to useful results with the hand refractometer.

Greater attention has been paid to the matter in Queensland where a scale of payment has been adopted providing that 85 per cent. of the recoverable sugar over and above 12 per cent. is paid to the grower, and the subject in its Queensland bearing is discussed by H. W. Kerr. In view of this importance, a committee was appointed and functioned for two years. Its reports have already been reviewed (1) and are summarized here. The basis of the method is found in the fact that, at maturity, the composition of the juice is essentially uniform throughout the length of the stalk. At first, ten canes were taken at random, divided into three equal lengths and the juice from the top, middle and bottom sections analysed for Brix, pol. and reducing sugar, the C.C.S. being calculated from the former two. Subsequent development consisted in refinement of methods, particularly in the determination of reducing sugars for which a rapid colorimetric method is described. To reduce the labour of cutting and transportation a piercer was designed by which a small quantity of juice could be extracted from a large number of stalks and reliable refractometer Brix determined immediately, the balance of the juice being preserved to avoid inversion pending analysis. For comparable results it became necessary to define the point in the top section of the cane at which the borer should be inserted. For the determination of C.C.S. a chart was designed by which this could be read off directly.

While a practicable harvesting scheme could not be devised on these tests alone, it is suggested that they would, after a few years' extensive study, help to indicate whether a re-allocation of relative areas devoted to early, medium or late-maturing canes is desirable; whether any adjustment of the fertilizing programme is desirable and whether it would be economical to leave certain portions of stalk in the field when damaged by frost or otherwise, and that a review of the preliminary test results would determine the date of the commencement of milling operations.

B. Viswa Nath and S. Kasinath described at some length the work, started in 1914, which led them to develop the top/bottom ratio method for determining the maturity of the sugar-cane. This method is based on the determined fact that, as the cane ripens, the concentration of the total solids in the juice of the top and bottom halves of the cane tends to equality. The method consists of calculating the ratio of the Brix

(1) *I. S. J.*, 1933, p. 381; 1934, p. 335.

determined for the top and bottom halves of the cane cut to the highest dead leaf joint. Since the ratio is independent of variations due to soil and season it is claimed that the method forms a more reliable guide than judgments based on sugar/Brix or glucose/sucrose ratios.

The method has been under trial under field conditions and while, generally, a steady increase in the quality of the juice accompanied an increase in the ratio, there occurred numerous instances in which there was an improvement in the quality of the juice although the ratio indicated maturity in the crop. It appears that, while the ratio remains constant at about 0.95, large improvements in the Brix and sucrose contents may occur, indicating that the crop is still growing. These observations led to a study of the methods of sampling and a comparison between the ratio as determined on adequate samples and jaggery yields, in which the concordance is adequate.

The behaviour of the ratio after it attains unity has not been definitely worked out but it appears that, after remaining steady for some time, it increases with over-ripeness. Such a rise of the ratio is shown to occur when the cane arrows.

It would appear from determinations made, that the method is applicable to the sugar cane-Sorghum hybrids. On the basis of the ratio, Co. 357 ripens between 197 and 227 days.—(*Int. Sugar Journal*, Vol. XXXVIII, No. 454, pp. 371-372, 1936.)

MISCELLANEOUS NOTES.

Yellowing and Die-Back of Coffee in Tanganyika.

An investigation into the cause of leaf-yellowing and die-back of coffee is described in the Annual Report for 1935 of the Tanganyika Department of Agriculture. Solution cultures, containing toxic concentrations of various ions (sodium, calcium, chloride, sulphate, nitrite, borate), were prepared, and the cut ends of coffee stems were immersed in them in order to trace the development of the leaf symptoms produced by the uptake of these ions. Although various symptoms were produced, none of them resembled the typical leaf-yellowing shown by coffee plants in the field. Accordingly, a lack of some rare soil element was suspected as the cause. A survey of the manganese content of the main types of coffee soils revealed the fact that volcanic ash soils, rich in the major nutrients, contained characteristically small quantities of exchangeable manganese, which was often associated with the appearance of coffee leaf-yellowing. The manganese content of leaves of affected plants furthermore contained significantly lesser amounts of manganese than those of healthy plants growing in the vicinity. Evidently manganese deficiency may be the main cause of coffee leaf-yellowing, and definite proof of this supposition is being sought by injecting solutions of manganese salts directly into the stems of affected plants.

* * *

Electricity in Horticulture.

Electro-culture has to take into account the effects of electric heating, electric lighting and the voltage stress on the life of plants. The first application of electricity took the form of high-voltage discharges produced in close proximity to various plants in an endeavour to obtain artificial stimulation. In the Engineering Supplement for May of *Siemens Magazine*, a survey is given of recent developments, and the photographs shown of the effects produced are convincing. It has often been noticed that an increased growth of crops sometimes occurs during thundery weather. In the Arctic where the average atmospheric potential gradient is high, it has been observed that the growth of vegetation during the short summer is more vigorous than in southern climates. Experiments have been carried out on cereals, potatoes, beets, tomatoes, strawberries and raspberries, and increases up to forty per cent. have been obtained. Electricity in the form of light was the next application in the aid of horticulture. For vigorous plant growth a minimum of about 4 hours of sunshine and altogether about 10 hours of daylight per day are required. As as example of the effect obtained by providing lighting for 10 hours each night with an illumination of about 4 foot candles, pansies after 83 days gave an average of approximately 16 flowers per plant as against 2 flowers for unlighted plants; and asters after 157 days' treatment bloomed 33 days earlier than usual. The red-yellow rays accelerate growth by stimulating the chlorophyll and the absorption of carbonic acid. Electric cables are also described which are used for heating the soil, and excellent economical results have been obtained.—(*Nature*, Vol. CXXXVIII, No. 3480, pp. 70-71, 1936.)

* * *

Control of Downy Mildew of Tobacco.

An interesting method of controlling the fungus disease known as downy mildew, or blue mould, of the tobacco plant, is reported in an account by Science Service from Canberra, Australia. This describes the work of Dr. H. R. Angell, Messrs. J. M. Allan and A. V. Hill, who have shown that early infection can be prevented by raising seedlings in an atmosphere containing vapour of benzol or toluol. Special seed-beds covered with glass have been prepared, and numerous shallow vessels containing the benzol or toluol are placed within. The young seedlings make healthy growth, and when transplanted do not contract the disease. Large scale field tests are in progress, and their results will be awaited with interest—(*Nature*, Vol. CXXXVIII, No. 3486, p. 334, 1936.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Promotion of Nitrogen Fixation in Tropical Soils.

At intervals since the beginning of the present century studies have been made of the value of molasses as a soil improver, and a number of investigators have examined the possibility that the action of the molasses was partly an indirect one, that of increasing nitrogen fixation. As there has been a certain conflict of results, particularly on the practical side, there is room for further investigation of the problem, and the contributions of Prof. N. R. Dhar and his co-workers at the University of Allahabad are to be welcomed. They have already shown considerable nitrogen fixation under tropical conditions when energy-rich materials such as soluble carbohydrates or molasses are added to the soil. They are now attacking the general problem of increasing soil nitrogen by supplying the nitrogen-fixing organisms with sources of energy, and in a recent communication to the Editor of *Nature* Prof. Dhar and Mr. S. K. Mukerji report appreciable gains in nitrogen content when soils, to which filter paper, dried leaves, or leaf juice had been added, were kept under laboratory conditions for several months. There were still greater increases in nitrogen content when molasses was also added, while soils exposed to sunlight for six hours daily gained slightly more than those kept in the dark. Sodium salts of organic acids, namely, sodium citrate, stearate, palmitate and oleate, exposed to light under similar conditions gave smaller but consistent increases in soil nitrogen. From one-half to two-thirds of the added carbon was oxidized at the same time. The authors point out that since molasses and cellulosic materials not only increase the humus content of the soil and improve its physical condition, but also promote nitrogen fixation the manuring of tropical soils with such substances should be a highly important practical proposition. —(*Nature*, Vol. CXXXVIII, No. 3493, p. 649, 1936.)

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Avocado Oil.

Avocado oil is prepared from fruit which has been scarred or blemished, so that it is not suitable for marketing as fresh fruit. Fuerte, Puebla and Mexican varieties, which are particularly suitable for oil extraction purposes, contain from 15 to 30 per cent. of oil in the edible fleshy portion. After peeling and removing the seed, the flesh is thinly sliced, placed on trays and dehydrated in an atmosphere of nitrogen or carbon dioxide at 130°F. The dried slices are then ground and pressed to yield the oil. It has been suggested that since avocado oil has a digestibility coefficient, equal to that of butter, is rich in vitamins, and is free from the objectionable odour and unpleasant taste of cod liver oil, it should not be difficult to establish it as a valuable article of commerce. —(*Food*, Vol. V, No. 60, p. 479, 1936.)

Hormones and Plant Development.

The effect of treating oat seeds with a solution of a growth hormone on the subsequent yield has been described by Dr. N. G. Cholodny (a Russian plant physiologist working at Kiev, U.S.S.R.), in a letter to *Nature*, 3rd October, 1936, p. 586. The bases of Dr. Cholodny's idea is the hypothesis that vernalisation operates by causing an increase in the concentration of the growth hormone in the cells of the embryos of the treated seeds. Oat seeds were soaked in a solution of indolyl acetic acid (a substance known to possess the properties of a growth hormone) and subsequently sown in soil. The growth of the seedlings was found to be much more vigorous than that of unsoaked seeds employed as "control". The quantity of grain eventually reaped from the hormonised oats was 55 per cent. greater than that produced by the control plants. It is thus possible that the treatment of seeds with solutions of growth stimulating substances may find application in agriculture.

* * *

Original Laterite of Buchanan.

Much of the controversy as to the nomenclature of laterites has resulted from the fact that no exact data concerning Buchanan's original laterite have been available. In order to settle the question, Dr. C. S. Fox, visited the type localities in Malabar during 1933. His results are now published (*Rec. Geol. Sur. India*, 389-422 ; 1936). From this paper, it is clear that Buchanan's laterite consists mainly of what would now be called lithomargic laterite and even, in part, lateritic lithomarge. The rocks studied by Buchanan represent but a stage in the passage from granites and gneisses, through kaolin or lithomarge, to a rock consisting mainly of hydrated oxides of alumina and iron in which combined silica is characteristically absent. The latter portion of this process of weathering is now generally known as lateritization, and the finished product is called laterite. Thus Buchanan's 'laterite' is an intermediate form needing some qualifying adjective such as *lithomargic*. Dr. Fox has shown a sense of proportion in recognizing the facts of present usage. Otherwise, had he insisted on a purely academic application of the law of priority, the term laterite would have to be restricted to the lithomargic rocks studied by Buchanan ; a completely new term would have to be adopted for the high-level fully formed laterites of the Deccan and elsewhere ; and the term laterization would have to be abandoned. Fortunately, there is no suggestion that any such confusion is likely to be introduced.—(*Nature*, Vol. CXXXVIII, No. 3493, p. 649, 1936.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.):—

	Foreign.		*Preferential.*	
	s.	d.	s	d.
26th November ..	4	9¾	8	6¾
3rd December ..	4	9¾	8	6¾
10th December ..	4	9¾	8	6
17th December ..	5	0	8	8¼
24th December ..	5	2¼	8	11¼
31st December ..	5	6¾	9	3¾
7th January ..	5	8¼	9	5¼
14th January ..	6	3	10	0
(16th *January*, 1936)	5	0¾	8	10½

After ruling quiet for some time the market assumed a decidedly firm and active tone and quotations have shown a considerable improvement. Apart from the factors of higher freight rates and almost total absence of first hand offerings of full duty sugars there can be little doubt that the margin of excess between supply and demand has now been reduced to a point where unexpected developments could easily tip the scale in favour of the article. According to Dr. Mikush's world statistics, consumption has risen since 1933-34 from a little over 25 million metric tons to 28 million metric tons in 1935-36 with the result that production was again short by a matter of 900,000 tons. Very large inroads have thus been made into surplus stocks.

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows:—

	Pence per lb.
25th November ..	8¾
2nd December ..	8 7-8
9th December ..	9 1-16
16th December ..	9 11-16
23rd December ..	10 1-8
30th December ..	10 11-16
6th January ..	10 9-16
13th January ..	10 3-4
(15th *January*, 1936) ..	6 11-16

Since our last report the market has been very active and there have been substantial advances in prices. The improvement has been due in a large measure to further declines in United Kingdom stocks, scarcity of spot and near rubber and heavy buying from America. The International Rubber Regulation Committee also fixed production quotas at 75 per cent. of the standard tonnages for the first quarter of 1937 and 80 per cent. for the second quarter. American consumption for November was 50,303 tons, total consumption for the first eleven months of 1936 amounting to 523,893 tons against 454,206 tons for the same period in 1935.

COCOA.—With the close of the year it was generally estimated that 60 to 70 per cent. of the West African crops had been sold to consuming markets, not all of which had been purchased by shippers from the natives. Deliberate selling pressure was noticed at various intervals in order to depress prices and at the same time dislodge native supplies. Recent reports indicate that most crops will show a shortage below that of last year due to prevailing weather conditions affecting crops. Accra cocoa has been quoted at 53*s.* 3*d.* *ex* warehouse and locally $15.25 is paid for Plantation Cocoa.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian F.G.F. Sakel.*
27th November ..	6.72	11.45
4th December ..	6.81	10.80
11th December ..	6.93	10.73
18th December ..	6.88	14.29
23rd December ..	6.94	10.12
31st December ..	7.10	10.40
8th January ..	7.11	—
15th January ..	7.20	—
(17th *January*, 1936)	6.13	9.57

There has been a tendency for prices to rise, and the consumption of raw cotton, especially in the United States, remains on a high level. The demand for West Indian Sea Island has continued active and all arrivals have been quickly purchased at advancing prices.

* * *

BANANAS.—Demand has been very slow in consequence of unfavourable weather conditions, Jamaicas remaining unchanged at £17 5*s.* per ton delivered London and £17 nearest station Provinces. Brazilians are £2 per ton lower at £12 delivered London and £14 Provinces.

* * *

GRAPEFRUIT.—Small quantities available from Trinidad ranging from 15*s.* to 16*s.* per case. A few cases of special quality fruit sold at 19*s.* per case (December 14th).

* * *

COFFEE.—Market for Kenyas was strong for all good to fine liquoring parcels, top price paid being 129*s.* 6*d.* Costa Ricas were a very poor market, quality in most instances not being up to Home Trade requirements. Some common quality mountain grown Jamaica fetched 85*s.* Superior Santos 47*s.* 6*d.* per cwt.